WASTE MANAGEMENT

WASTE MANAGEMENT
OF ILLINOIS
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September 22, 2014

Mr. Ray Pilapil, Manager
Illinois Environmental Protection Agency
Bureau of Air – Permit Section
1021 North Grand Avenue East
Springfield, Illinois 62794

Cottonwood Hills Recycling & Disposal Facility - Source ID No. 163075AAL
Additional Information to CAAPP Renewal Application (Revised NSPS Design Plan)

Dear Mr. Pilapil:

This letter and its attachments have been prepared as Additional Information to the Clean Air Act Permit Program (CAAPP) Renewal Application submitted for Agency approval on January 25, 2007 for the Cottonwood Hills Recycling & Disposal Facility (RDF) located in Marissa, Illinois. The IEPA (via email dated September 4, 2014) requested the facility to revise the original NSPS Design Plan. Revisions were to include the most current gas collection and control system as-built drawings and removal of all alternative requests that have not been previously approved by USEPA at other landfills.

Since the CAAPP permit is currently open due to a pending renewal, a CAAPP Form 505 is provided in lieu of a CAAPP Form 200.

If you have any questions regarding this submittal or need additional information, please contact me at (314) 568-2025.

Sincerely,
Waste Management of Illinois, Inc.

Ernest H. Dennison

Ernest H. Dennison, P.E.
District Engineer

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF AIR POLLUTION CONTROL -- PERMIT SECTION
P.O. BOX 19506
SPRINGFIELD, ILLINOIS 62794-9506

FOR APPLICANT'S USE
Revision #: ______
Date: ___ / ___ / ___
Page ___ of ___
Source Designation: ______

SUPPLEMENT TO CAAPP APPLICATION	*FOR AGENCY USE ONLY*
	ID NUMBER:
	PERMIT #:
	DATE:

THIS FORM SHALL ACCOMPANY ANY SUPPLEMENT TO A CAAPP APPLICATION, THAT IS, ANY SUBMITTAL OF NEW OR CORRECTED INFORMATION FOR A PENDING CAAPP APPLICATION.

SOURCE INFORMATION	
1) SOURCE NAME: Cottonwood Hills Recycling & Disposal Facility	
2) DATE FORM PREPARED: September 2014	3) SOURCE ID NO. (IF KNOWN): 163075AAL

SUPPLEMENT INFORMATION	
4) DOES THIS SUPPLEMENT PROVIDE ADDITIONAL INFORMATION? IF YES, COMPLETE THE FOLLOWING:	☒ Yes ☐ No

NUMBER OF NEW PAGES IN THIS SUPPLEMENT: See Below

EMISSION UNIT, EQUIPMENT, OR SUBJECT THAT THIS SUPPLEMENT ADDRESSES	UNIT DESIGNATION	NEW PAGE #(S)
Form 505 – Supplement to CAAPP Application	N/A	505-1 & 505-2
Updated NSPS Landfill Gas Collection and Control System Design Plan	MSW Landfill	

THIS AGENCY IS AUTHORIZED TO REQUIRE THIS INFORMATION UNDER ILLINOIS REVISED STATUTES, 1991, AS AMENDED 1992, CHAPTER 111 1/2, PAR. 1039.5. DISCLOSURE OF THIS INFORMATION IS REQUIRED UNDER THAT SECTION. FAILURE TO DO SO MAY PREVENT THIS FORM FROM BEING PROCESSED AND COULD RESULT IN THE APPLICATION BEING DENIED. THIS FORM HAS BEEN APPROVED BY THE FORMS MANAGEMENT CENTER.

APPLICATION PAGE ______

FOR APPLICANT'S USE ______

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505-CAAPP

5) DOES THIS SUPPLEMENT CORRECT PREVIOUSLY SUBMITTED INFORMATION? ■ Yes ☐ No

IF YES, COMPLETE THE FOLLOWING:

NUMBER OF REVISED PAGES IN THE SUPPLEMENT: ____________

	EMISSION UNIT, EQUIPMENT, OR SUBJECT THAT THIS SUPPLEMENT ADDRESSES	UNIT DESIGNATION	OLD PAGE #(S)	NEW PAGE #(S)	

SIGNATURE BLOCK

6) I CERTIFY UNDER PENALTY OF LAW THAT, BASED ON INFORMATION AND BELIEF FORMED AFTER REASONABLE INQUIRY, THE STATEMENTS AND INFORMATION CONTAINED IN THIS APPLICATION, AS AMENDED BY THIS SUPPLEMENT, ARE TRUE, ACCURATE AND COMPLETE.

AUTHORIZED SIGNATURE:

BY:	Ernest H Dennison	**District Engineer**
	AUTHORIZED SIGNATURE	TITLE OF SIGNATORY
	Ernest Dennison	9 / 22 / 14
	TYPED OR PRINTED NAME OF SIGNATORY	DATE

FOR APPLICANT'S USE
Revision #: ______
Date: ___ / ___ / ___
Page ______ of ______
Source Designation: ______

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF AIR POLLUTION CONTROL -- PERMIT SECTION
P.O. BOX 19506
SPRINGFIELD, ILLINOIS 62794-9506

DELEGATION OF AUTHORITY FOR RESPONSIBLE OFFICIAL TO A REPRESENTATIVE	***FOR AGENCY USE ONLY***
	ID NUMBER:
	PERMIT #:
	DATE:

THIS FORM SHALL BE USED BY A RESPONSIBLE OFFICIAL TO DELEGATE AUTHORITY TO A REPRESENTATIVE OF SUCH PERSON FOR SIGNATURE ON APPLICATIONS OR CERTIFICATION OF REPORTS TO BE SUBMITTED PURSUANT TO THE CLEAN AIR ACT.

THIS FORM SHALL ONLY BE USED FOR A CORPORATION AT WHICH A PRESIDENT, SECRETARY, TREASURER, OR VICE-PRESIDENT OF THE CORPORATION IN CHARGE OF BUSINESS FUNCTION, OR ANY OTHER PERSON WHO PERFORMS SIMILAR POLICY OR DECISION MAKING FUNCTIONS FOR THE CORPORATION TO TRANSFER THE AUTHORITY AS A RESPONSIBLE OFFICIAL TO A REPRESENTATIVE OF SUCH PERSON. THE REPRESENTATIVE OF SUCH PERSON MUST BE RESPONSIBLE FOR THE OVERALL OPERATION OF ONE OR MORE MANUFACTURING, PRODUCTION, OR OPERATING FACILITIES APPLYING FOR OR SUBJECT TO A PERMIT.

NOTE: THIS TRANSFER OF DELEGATION OF AUTHORITY IS APPLICABLE ONLY IF THE FACILITY EMPLOYS MORE THAN 250 PERSONS OR HAS A GROSS ANNUAL SALES OR EXPENDITURES EXCEEDING $25 MILLION (IN SECOND QUARTER 1980 DOLLARS).

SOURCE INFORMATION	
1) SOURCE NAME: Cottonwood Hills Recycling and DIsposal Facility	
2) DATE FORM PREPARED: 2/3/14	3) SOURCE ID NO. (IF KNOWN): 163075AAL

TRANSFER OF AUTHORITY

4) I, THE UNDERSIGNED, BEING A PRESIDENT, SECRETARY, TREASURER, OR VICE-PRESIDENT OF THE CORPORATION IN CHARGE OF BUSINESS FUNCTION, OR OTHER PERSON WHO PERFORMS SIMILAR POLICY OR DECISION MAKING FUNCTIONS FOR THE CORPORATION, HEREBY TRANSFER THE AUTHORITY AS A RESPONSIBLE OFFICIAL TO Ernest H Dennison, THEY BEING A REPRESENTATIVE AND RESPONSIBLE FOR THE OVERALL OPERATION OF ONE OR MORE MANUFACTURING, PRODUCTION, OR OPERATING FACILITIES APPLYING FOR OR SUBJECT TO A PERMIT.

[signature]	Vice President and Assistant Secretary
AUTHORIZED SIGNATURE	TITLE OF SIGNATORY
Dennis M. Wilt	2 / 3 / 14
TYPED OR PRINTED NAME OF SIGNATORY	DATE
Ernest H Dennison	District Engineer
DELEGATED REPRESENTATIVE	TITLE OF DESIGNATED REPRESENTATIVE

THIS AGENCY IS AUTHORIZED TO REQUIRE THIS INFORMATION UNDER ILLINOIS REVISED STATUTES, 1991, AS AMENDED 1992, CHAPTER 111 1/2, PAR. 1039.5. DISCLOSURE OF THIS INFORMATION IS REQUIRED UNDER THAT SECTION. FAILURE TO DO SO MAY PREVENT THIS FORM FROM BEING PROCESSED AND COULD RESULT IN THE APPLICATION BEING DENIED. THIS FORM HAS BEEN APPROVED BY THE FORMS MANAGEMENT CENTER.

FOR APPLICANT'S USE
______

APPLICATION PAGE ______

Revised NSPS Collection and Control System Design Plan For Cottonwood Hills RDF

Source I.D. No. 163075AAL
CAAPP Permit No. 01040051

Marissa, Illinois

Prepared in Accordance with
40 CFR 60 Subpart WWW

September 2014

Prepared By:

Environmental Information Logistics, LLC
130 E. Main Street
Caledonia, Michigan 49316

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SECTION I

INTRODUCTION AND GENERAL SITE CHARACTERISTICS

INTRODUCTION AND GENERAL SITE CHARACTERISTICS

Applicability

The Cottonwood Hills Recycling and Disposal Facility began accepting waste in November, 2000. The landfill has a design capacity of 39,448,850 bank cubic yards. This is greater than 2,500,000 cubic meters. Therefore, the landfill is therefore subject to the New Source Performance Standards (NSPS) for municipal solid waste landfills, promulgated March 12, 1996.

For several years, the facility was able to demonstrate NMOC emissions of less than 50 Mg/year using the results of Tier 2 testing. The facility exceeded the 50 Mg/year NMOC emissions rate in 2007 (as provided in the annual NMOC rate report dated June 1, 2007). The site was therefore required to submit a collection and control system design plan to the Administrator (i.e., the IEPA) for approval within one year of submittal of the NMOC emissions calculations showing emissions greater than 50 Mg/year. The original NSPS Design Plan was submitted to IEPA on May 27, 2008.

In September 2014, the IEPA required the facility to revise the original NSPS Design Plan. Revisions were to include the most current gas collection and control system as-built drawings and removal of all alternative requests that have not been previously approved by USEPA at other landfills.

The submittal of this revised document fulfills the requirement for the facility to prepare a collection and control system design plan in accordance with 40 CFR 60.752(b)(2). The design plan outlines the methodology employed to design a landfill gas management system that will collect and dispose of the landfill gas generated in the entire permitted landfill at final grades.

As-built drawings of the currently installed gas collection system are provided in Appendix A, as well as the design for the future gas collection system. In addition, the facility's proposed methods for complying with the monitoring record keeping and reporting requirements of the NSPS, and alternatives the site plans to implement that have been previously approved by USEPA at other landfills, are presented in Section III of the plan. A surface monitoring plan is also presented.

Since the Cottonwood Hills RDF operates under a Clean Air Act Permit, this design plan is presented in the format of additional information to the CAAPP renewal application, which was submitted to IEPA on January 25, 2007.

This NSPS required collection and control system design plan is based on the final grades of the active solid waste landfill. The Cottonwood Hills RDF is currently at interim grades. The evolution of the collection and control system as the landfill is filled will ultimately produce the design specified in this plan. Until the landfill has attained its permitted final grades, the collection and control of landfill gas pursuant to the NSPS may be accomplished using methods not specifically included as part of the final design (i.e. horizontal gas collection trenches, collection from leachate sumps and risers, etc.). However, once the facility has reached the final permitted grades, the collection and control system will meet the criteria specified within this design plan.

The NSPS requires that several additional items be addressed in the design plan, such as depths of refuse, cover properties, compatibility with filling operations, integration with closure end use, and minimization of off-site migration. These items are discussed in this section, since they are not referenced in other areas of the design plan.

Site Background

The Cottonwood Hills RDF is located in St. Clair County, Illinois. The facility began accepting waste in November, 2000. The waste footprint is 203 acres in size, of which approximately 63 acres have been constructed and approximately 24 acres have been final covered. The facility is projected to close approximately in the year 2065. However, the actual closure date will depend on refuse acceptance rates.

Summary of Current and Proposed Landfill Gas Controls

The Cottonwood Hills RDF has a gas collection system in place that consists of 22 vertical gas extraction wells. Collected gas is sent to an open flare for combustion.

Once the facility has reached its permitted final grades and is closed, the gas collection system will ultimately consist of 79 vertical gas extraction wells and associated header piping. Gas will continue to be sent to an open flare for combustion, unless it is used beneficially for energy recovery.

Gas Well Decommissioning

The following steps will be initiated for decommissioning a well:

- Obtain Agency approval for the permanent decommissioning via submittal of a Minor Modification to the CAAPP permit (effective as of the date of filing).
- Disconnection of well from collection system (removal of flex hose, capping of header lateral, etc.). Once disconnected, monthly wellhead monitoring will not be performed on the well.
- Physical abandonment (cut off wellhead below ground, cap and backfill). Physical abandonment may not be performed immediately following well disconnection. Timing of the physical abandonment of the well will depend on weather conditions or the potential for the well to recover sufficient gas flows.

GCCS Design Changes:

Installation of GCCS components is anticipated to coincide with stages of fill development and NSPS regulations regarding installation of GCCS components stipulated in §60.752(b)(2)(ii)(A)(2). The GCCS design presented in this Design Plan may be altered slightly to accommodate actual field conditions at the time of construction, but will still meet the operational provisions of the NSPS.

Installation and Startup of New Gas Wells:

New gas extraction wells will be installed as required by §60.753(a)(1) to ensure that landfill gas is being collected from each area, cell or group of cells in the landfill in which solid waste has been in place for 5 years or more if active or 2 years or more if closed or at final grades. The gas collection well field will need to be "tuned" once new gas extraction wells are installed to return the system to a state of equilibrium. Adjustments will be made to the vacuum being applied to the new gas extraction well and other nearby wells.

Landfill Unit/Area Exclusions:

No areas of the landfill have been excluded from coverage of the GCCS in accordance with 60.759(a)(3)(i) as a result of asbestos placement, or the placement of non-degradable material. In addition, no areas of the landfill were determined to be non-productive (i.e., contribute <1 percent of the total amount of NMOC emissions from the landfill) in accordance with 60.759(a)(3)(ii); therefore, no areas of the landfill have been excluded from coverage of the GCCS.

Depths of Refuse

Depths of refuse at the Cottonwood Hills RDF range from approximately 50 feet to 200 feet.

Cover Properties

Final cover at the Cottonwood Hills RDF is currently expected to consist of the following (from the top of the final cover down):

- 36 inches of protective cover soil
- 36 inches of low permeability, compacted soil

Landfill Gas Control System Expandability

Expandability of the GCCS is achieved by installing blind flanges along the transmission piping, which allows the LFG transmission piping to be easily expanded in the future. In the event that actual LFG flow rates do exceed the capacity of the system, additional GCCS components will be designed and installed in accordance with NSPS requirements.

Leachate/Condensate Management

Condensate from the gas collection system is co-mingled with the landfill leachate for disposal. The facility disposes of landfill liquids at the Village of Marissa POTW.

Compatibility with Filling Operations

Gas extraction wells will be installed within 60 days of the date in which the initial solid waste has been in place for a period of 5 years or more if active or 2 years or more if closed or at final grade. Methods for gas collection may include vertical gas extraction wells, extraction from the leachate collection system, horizontal trenches, passive vents or flares, etc. The methods selected for each area will take into account the stage of filling operations occurring in the area, in order to minimize damage to the collection system from landfill traffic.

As refuse filling operations proceed and portions of the site reach final or near-final grades, additional GCCS components will be installed. Using this method allows GCCS components to be installed in accordance with §60.752(b)(2)(ii)(A)(2)(i) and (ii) while minimizing interference of the GCCS with ongoing filling operations.

Accessibility

Accessibility to the GCCS components is achieved by installing commonly accessed components (such as wellheads, monitoring ports, etc.) on relatively flat surfaces of the landfill or near the landfill's road network. Since the GCCS will be predominately installed below grade, valves and monitoring ports will be installed above grade, or within vaults, to increase their accessibility.

Integration with Closure End Use

Future land use for the Cottonwood Hills RDF will be determined upon closure of the facility. The end use plan shall comply with IEPA regulations and shall not disturb the integrity of the gas control system, final cover system, or any other components of the containment or monitoring system.

Air Intrusion Control

Air intrusion and LFG emissions will be controlled through periodic monitoring and adjustment of the GCCS in coordination with appropriate maintenance of the landfill cover system. Further, air intrusion control will be accomplished through monitoring of the operational monitoring standards for the LFG collection elements in accordance with NSPS requirements. If the GCCS does not meet the operational monitoring standards, it will be adjusted or modified in accordance with NSPS requirements

Corrosion Resistance

Corrosion resistance of the GCCS is achieved through the use of corrosion resistant materials or materials that have a corrosion resistant coating, in accordance with 40 CFR§60.759(b)(1). The primary components used in the construction of the GCCS are HDPE and PVC piping or other non-porous corrosion resistant material.

Fill Settlement

Settlement will occur due to decomposition of the refuse. To accommodate refuse settlement, the GCCS components were designed and installed with several features to account for this settlement including:

- LFG extraction wellheads connected to the LFG transmission piping via a flexible pipe or hose connection. This allows the LFG piping to accommodate changes in the orientation of the LFG transmission piping or LFG extraction well.

- LFG transmission piping was sloped at sufficient grades so that reasonable amounts of differential and total settlement may occur without causing pipe breakage, or disrupting the overall flow gradient of the LFG transmission piping.

- HDPE piping will be used for the construction of the header piping and transmission system. HDPE piping is flexible and absorbs differential settlement without breaking or cracking.

Resistance to Decomposition Heat

Resistance of the GCCS to the heat generated as a result of refuse decomposition was achieved through the use of materials tested and proven to withstand temperatures well above those typically found in landfills. Landfill gas temperature will be monitored periodically in accordance with operational monitoring standards for the LFG collection elements as required by NSPS. The GCCS will be adjusted or modified to mitigate potential affects of elevated temperatures when warranted.

Minimization of Off-Site Migration

The installation and operation of an active gas recovery system causes an inward pressure gradient at the landfill, which will serve to minimize off-site migration of landfill gas. The facility performs perimeter gas monitoring in accordance with IEPA regulations. This monitoring will help to measure the effectiveness of the gas collection system at minimizing off-site migration.

SECTION II

ENGINEERING CALCULATIONS

CALCULATION OF MAXIMUM GAS FLOW RATE

INTRODUCTION

The NSPS states that "gas mover equipment... be sized to handle the maximum gas generation flow rate expected over the intended use period of the gas moving equipment" (40 CFR 60.759[c]). A calculation to estimate this maximum gas generation flow rate must be performed in accordance with 40 CFR 60.755(a)(1). The following equation was utilized for calculating the maximum gas flow rate for the Cottonwood Hills RDF:

$$Q_M = \sum_{i=1}^{n} 2k\, L_o\, M_i\,(e^{-kt_i})$$

Where: Q_M = maximum expected gas generation flow rate, cubic meters per year
k = methane generation rate constant, year $^{-1}$
L_o = methane generation potential, cubic meters per megagram solid waste
M_i = mass of solid waste in the i^{th} section, megagrams
t_i = age of the i^{th} section, years

The NSPS states that the k and L_o kinetic factors should be those published in the most recent compilation of Air Pollutant Emission Factors (AP-42) or other site specific values demonstrated to be appropriate and approved by the Administrator.

It is requested that the facility be permitted to use kinetic factors from a database compiled by Waste Management in the calculation of the maximum gas flow rate. The database contains gas generation rates measured at over two dozen Waste Management MSW landfills during gas extraction tests conducted in the 1980s. The landfills were sited across varying geographical regions of the United States in order to assess the effect of location and climate on gas generation rates. Data on these pump tests was provided to the EPA's Office of Air Quality Planning and Standards in 1988 and 1989 as background information for the development of the NSPS. The gas extraction tests conducted in the 1980s are very similar to the Tier III testing described in the NSPS.

A summary of the database is provided in Table 1. The selection of appropriate kinetic factors for the facility is discussed in the next subsection.

SELECTION OF EQUATION PARAMETERS

Methane Generation Rate Constant k:
In lieu of conducting Tier 3 testing at the facility, the database of gas generation rates measured at several landfills was utilized to select a k value (generation rate constant) suitable to the Cottonwood Hills RDF.

Several characteristics of the site were compared to the landfill records in the database. Since the site is located in the midwestern United States, only sites of similar refuse volume capacity and waste stream characterization which have comparable precipitation amounts were utilized in the comparison. It is assumed that the methanogenic process is mesophilic with microbial activity generating landfill gas temperatures less than 100 degrees Fahrenheit. The type of microbial environment has an impact on design considerations as well as determining an appropriate gas generation rate.

Landfills that exhibit mesophilic characteristics have a slightly lower gas generation rate than the average thermophilic landfill environment. However, the lower gas generation rate noted at mesophilic sites is less related to the type of bacteria as compared to other factors, such as the types of waste, lack of addition of wastewater sludge, and the quantity of rainfall and liquids in the landfill. A gas generation rate of **0.105 cubic feet per pound of refuse per year** most closely approximates the rate which is anticipated for the Cottonwood Hills RDF.

In order to convert the gas generation rate to the methane generation rate constant k, the gas generate rate is divided by the theoretical landfill gas yield per pound of refuse (as discussed in the next subsection). This results in a k value of **0.0233 year^{-1}**.

Methane Generation Potential L_0:

The next input into the gas flow rate equation is the theoretical maximum yield (expected volume of gas per unit mass of refuse). Determining the maximum theoretical yield of a unit mass of municipal solid waste is a difficult task. Either of two methods can be used: (1) stoichiometric, or (2) biodegradability, but both methods require extensive sampling, time-consuming lab analyses, and difficult analytical procedures. Both methods are also heavily dependent on obtaining a characteristic sample of the waste stream.

Most samples, however, are small in size relative to the composite waste stream and often are not very characteristic of the biodegradability of the waste. In an evaluation of this nature, it is not practical to place much emphasis on characterizing the organic fraction of the waste stream unless large samples are collected.

Based on past experience, which included an extensive literature review and a review of data available on the typical United States waste stream, a theoretical yield of **4.5 cubic feet per pound of refuse** was derived for the facility. This value closely approximates observed landfill gas production in sites of similar characteristics.

In order to utilize theoretical yield (or "methane generation potential") in the gas generation equation, the value must be reported in terms of cubic meters of methane per megagram of solid waste rather than cubic feet of landfill gas per pound of refuse. After converting from English to metric units, and assuming that approximately 50 percent of landfill gas is comprised of methane, an L_0 value of **139.6 m^3 methane/megagram solid waste** was derived.

Mass of Solid Waste M_i:

The gas production volumes for the Cottonwood Hills RDF are based on actual gate receipts from 2000 to 2013, and future gate receipts from 2014 to the projected closure date of 2065.

This data forms the foundation of the gas volume projection and is subject to change over the active lifetime of the landfill. It also implies that the gas volume projection will vary accordingly. This variability does not pose a problem with gas management system design. The gas management system design at the facility is based on the expected gas production from the planned volumetric space of the landfill. Therefore, even though gas volumes may fluctuate over a period of time because of varying disposal rates, the ultimate total volume of gas projected for the site will remain constant and the gas collection system components will be sized accordingly.

It is anticipated that the projected future annual waste receipts at the Cottonwood Hills RDF will be approximately 500,000 tons/year for the facility. Refuse intake data is provided in Table 2.

Age of the "i^{th} section", t_i:

This age is automatically calculated with each iteration of the EPA model.

CALCULATION OF MAXIMUM GENERATION RATE

The EPA has simplified the gas generation rate calculation by providing an Excel-based program to the public. Therefore, the EPA's Landfill Air Emissions Estimation Model was utilized to predict maximum landfill gas generation volumes. The model output provides an estimation of total gas production volume.

Based on the model output provided in Attachment 1, the following maximum gas generation flow rate was estimated for the year 2065 for the Cottonwood Hills RDF:

Total LFG Production	=	9.707×10^7 m^3/year
	=	6,522 ft^3/min

TABLE 1: Database of Landfill Gas Generation Rates

Site ID	State	Measured Gas Generation Rate (ft^3/lb/yr)	Corresponding "k" Value (1/yr)*
A	Pennsylvania	.130	.029
B	Wisconsin	.126	.028
C	Wisconsin	.079	.018
D	Ohio	.116	.026
E	Michigan	.112	.025
F	Illinois	.130	.029
G	Colorado	.06	.013
H	Florida	.172	.038
I	New Jersey	.085	.019
J	New Jersey	.098	.022
K	New York	.147	.033
L	Texas	.112	.025
M	Colorado	.085	.019
N	Connecticut	.159	.035
O	Pennsylvania	.042	.009
P	Illinois	.124	.028
Q	California	.083	.018
R	Illinois	.142	.032
S	Texas	.095	.021
T	Kentucky	.108	.024
U	California	.065	.014
V	Maryland	.063	.014
W	New York	.094	.021
X	Ohio	.089	.02
Y	Ohio	.096	.021
Z	Ohio	.082	.018
AA	Massachusetts	.104	.023
BB	Ohio	.067	.015
CC	New Hampshire	.102	.023
DD	Illinois	.085	.019
EE	California	.109	.024
FF	Illinois	.075	.017

- k values were calculated by dividing the gas generation rate by the theoretical maximum gas production of 4.5 ft^3 landfill gas/lb of refuse.

TABLE 2: Refuse Intake Volumes

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2000	3,836	4,220	0	0
2001	259,005	284,906	3,836	4,220
2002	285,045	313,550	262,842	289,126
2003	348,385	383,223	547,887	602,676
2004	391,981	431,179	896,272	985,899
2005	408,196	449,016	1,288,253	1,417,078
2006	504,697	555,167	1,696,449	1,866,094
2007	436,431	480,074	2,201,146	2,421,261
2008	362,142	398,356	2,637,577	2,901,335
2009	450,445	495,490	2,999,719	3,299,691
2010	420,734	462,807	3,450,164	3,795,181
2011	466,614	513,275	3,870,898	4,257,988
2012	462,640	508,904	4,337,512	4,771,263
2013	412,982	454,280	4,800,152	5,280,167
2014	454,545	500,000	5,213,134	5,734,447
2015	454,545	500,000	5,667,679	6,234,447
2016	454,545	500,000	6,122,225	6,734,447
2017	454,545	500,000	6,576,770	7,234,447
2018	454,545	500,000	7,031,316	7,734,447
2019	454,545	500,000	7,485,861	8,234,447
2020	454,545	500,000	7,940,407	8,734,447
2021	454,545	500,000	8,394,952	9,234,447
2022	454,545	500,000	8,849,498	9,734,447
2023	454,545	500,000	9,304,043	10,234,447
2024	454,545	500,000	9,758,588	10,734,447
2025	454,545	500,000	10,213,134	11,234,447
2026	454,545	500,000	10,667,679	11,734,447
2027	454,545	500,000	11,122,225	12,234,447
2028	454,545	500,000	11,576,770	12,734,447
2029	454,545	500,000	12,031,316	13,234,447
2030	454,545	500,000	12,485,861	13,734,447
2031	454,545	500,000	12,940,407	14,234,447
2032	454,545	500,000	13,394,952	14,734,447
2033	454,545	500,000	13,849,498	15,234,447
2034	454,545	500,000	14,304,043	15,734,447
2035	454,545	500,000	14,758,588	16,234,447
2036	454,545	500,000	15,213,134	16,734,447
2037	454,545	500,000	15,667,679	17,234,447
2038	454,545	500,000	16,122,225	17,734,447
2039	454,545	500,000	16,576,770	18,234,447
2040	454,545	500,000	17,031,316	18,734,447
2041	454,545	500,000	17,485,861	19,234,447
2042	454,545	500,000	17,940,407	19,734,447
2043	454,545	500,000	18,394,952	20,234,447
2044	454,545	500,000	18,849,498	20,734,447

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2045	454,545	500,000	19,304,043	21,234,447
2046	454,545	500,000	19,758,588	21,734,447
2047	454,545	500,000	20,213,134	22,234,447
2048	454,545	500,000	20,667,679	22,734,447
2049	454,545	500,000	21,122,225	23,234,447
2050	454,545	500,000	21,576,770	23,734,447
2051	454,545	500,000	22,031,316	24,234,447
2052	454,545	500,000	22,485,861	24,734,447
2053	454,545	500,000	22,940,407	25,234,447
2054	454,545	500,000	23,394,952	25,734,447
2055	454,545	500,000	23,849,498	26,234,447
2056	454,545	500,000	24,304,043	26,734,447
2057	454,545	500,000	24,758,588	27,234,447
2058	454,545	500,000	25,213,134	27,734,447
2059	454,545	500,000	25,667,679	28,234,447
2060	454,545	500,000	26,122,225	28,734,447
2061	454,545	500,000	26,576,770	29,234,447
2062	454,545	500,000	27,031,316	29,734,447
2063	454,545	500,000	27,485,861	30,234,447
2064	454,545	500,000	27,940,407	30,734,447
2065	295,119	324,631	28,394,952	31,234,447

Attachment 1: Landfill Gas Generation Rate

Year	Total landfill gas		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*
2000	0	0	0
2001	3.054E+01	2.445E+04	1.643E+00
2002	2.091E+03	1.675E+06	1.125E+02
2003	4.313E+03	3.454E+06	2.320E+02
2004	6.988E+03	5.596E+06	3.760E+02
2005	9.949E+03	7.967E+06	5.353E+02
2006	1.297E+04	1.039E+07	6.979E+02
2007	1.669E+04	1.337E+07	8.982E+02
2008	1.979E+04	1.585E+07	1.065E+03
2009	2.222E+04	1.779E+07	1.196E+03
2010	2.530E+04	2.026E+07	1.361E+03
2011	2.808E+04	2.248E+07	1.511E+03
2012	3.115E+04	2.494E+07	1.676E+03
2013	3.413E+04	2.733E+07	1.836E+03
2014	3.664E+04	2.934E+07	1.971E+03
2015	3.942E+04	3.157E+07	2.121E+03
2016	4.214E+04	3.375E+07	2.267E+03
2017	4.480E+04	3.588E+07	2.411E+03
2018	4.740E+04	3.796E+07	2.550E+03
2019	4.994E+04	3.999E+07	2.687E+03
2020	5.243E+04	4.198E+07	2.821E+03
2021	5.485E+04	4.392E+07	2.951E+03
2022	5.722E+04	4.582E+07	3.079E+03
2023	5.954E+04	4.768E+07	3.203E+03
2024	6.180E+04	4.949E+07	3.325E+03
2025	6.402E+04	5.126E+07	3.444E+03
2026	6.618E+04	5.299E+07	3.561E+03
2027	6.829E+04	5.469E+07	3.674E+03
2028	7.036E+04	5.634E+07	3.785E+03
2029	7.238E+04	5.796E+07	3.894E+03
2030	7.435E+04	5.953E+07	4.000E+03
2031	7.628E+04	6.108E+07	4.104E+03
2032	7.816E+04	6.259E+07	4.205E+03
2033	8.000E+04	6.406E+07	4.304E+03
2034	8.180E+04	6.550E+07	4.401E+03
2035	8.356E+04	6.691E+07	4.496E+03
2036	8.528E+04	6.829E+07	4.588E+03
2037	8.696E+04	6.963E+07	4.678E+03
2038	8.860E+04	7.094E+07	4.767E+03
2039	9.020E+04	7.223E+07	4.853E+03
2040	9.177E+04	7.348E+07	4.937E+03
2041	9.330E+04	7.471E+07	5.020E+03
2042	9.480E+04	7.591E+07	5.100E+03

Year	Total landfill gas		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*
2043	9.626E+04	7.708E+07	5.179E+03
2044	9.769E+04	7.822E+07	5.256E+03
2045	9.908E+04	7.934E+07	5.331E+03
2046	1.004E+05	8.044E+07	5.404E+03
2047	1.018E+05	8.150E+07	5.476E+03
2048	1.031E+05	8.255E+07	5.546E+03
2049	1.044E+05	8.357E+07	5.615E+03
2050	1.056E+05	8.456E+07	5.682E+03
2051	1.068E+05	8.554E+07	5.747E+03
2052	1.080E+05	8.649E+07	5.811E+03
2053	1.092E+05	8.742E+07	5.874E+03
2054	1.103E+05	8.833E+07	5.935E+03
2055	1.114E+05	8.922E+07	5.995E+03
2056	1.125E+05	9.009E+07	6.053E+03
2057	1.136E+05	9.094E+07	6.110E+03
2058	1.146E+05	9.177E+07	6.166E+03
2059	1.156E+05	9.258E+07	6.220E+03
2060	1.166E+05	9.337E+07	6.274E+03
2061	1.176E+05	9.414E+07	6.326E+03
2062	1.185E+05	9.490E+07	6.376E+03
2063	1.194E+05	9.564E+07	6.426E+03
2064	1.203E+05	9.636E+07	6.475E+03
2065	**1.212E+05**	**9.707E+07**	**6.522E+03**
2066	1.208E+05	9.674E+07	6.500E+03
2067	1.181E+05	9.454E+07	6.352E+03
2068	1.154E+05	9.239E+07	6.208E+03
2069	1.128E+05	9.029E+07	6.067E+03
2070	1.102E+05	8.824E+07	5.929E+03
2071	1.077E+05	8.623E+07	5.794E+03
2072	1.052E+05	8.427E+07	5.662E+03
2073	1.028E+05	8.236E+07	5.534E+03
2074	1.005E+05	8.048E+07	5.408E+03
2075	9.822E+04	7.865E+07	5.285E+03
2076	9.599E+04	7.687E+07	5.165E+03
2077	9.381E+04	7.512E+07	5.047E+03
2078	9.168E+04	7.341E+07	4.932E+03
2079	8.959E+04	7.174E+07	4.820E+03
2080	8.755E+04	7.011E+07	4.711E+03

WELL PLACEMENT (DARCY RADIUS OF INFLUENCE CALCULATIONS)

INTRODUCTION

The first step in performing a gas system design is to lay out the location of the vertical gas extraction wells. The spacing (or horizontal distance) between the wells is determined by a calculated "Radius of Influence" (ROI). The ROI defines an area from which gas can be extracted without inducing excessive air into the landfill. General design criteria, the method for determining ROIs and well construction are discussed in the following subsections.

Well spacing is also the first requirement listed under 40 CFR 60.759: Specifications for Active Collection Systems. Specifically, each owner or operator seeking to comply with §60.752(b)(i) should site active collection wells, horizontal collectors, surface collectors, or other extraction devices at a sufficient density throughout all gas producing areas using the following procedures unless alternative procedures have been approved by the Administrator.

A gas collection system has already been installed over a portion of the landfill. As-builts of the system are included in Appendix A. The ability of these wells to meet the NSPS performance requirements are verified on a quarterly basis by the surface monitoring program required by the NSPS. Therefore, no calculations for the radius of influence (ROI's) have been provided for the existing wells in these systems.

A conceptual design for the remainder of the proposed gas system was prepared and drawings are included in Appendix A. A discussion on the methodology used to calculate well density is provided below.

DESIGN METHODOLOGY: DARCY RADIUS OF INFLUENCE

INTRODUCTION

The correct placement of vertical gas extraction wells is a critical component of the landfill gas control system design. The goal is to maximize the volume of gas extracted from the landfill without harming the landfill environment. Maximizing the volume of methane gas extracted will help minimize landfill emissions, reduce the occurrence of odors, minimize vegetative stress, and control potential subsurface gas migration.

When a well is placed under a vacuum, or negative pressure, the recoverable landfill gas in the immediate vicinity will begin to move towards it. This area of gas movement is called a well's "Radius of Influence", or ROI. For ease of calculation, the area is assumed to be cylindrical with the vertical well in the center of the cylinder. The edge of the ROI is reached when the pull of vacuum exerted by the well is zero; i.e., landfill gas will no longer move towards the well from beyond a certain point. The actual extent of influence will vary from well to well and cannot be measured until the well is actually installed. However, for design purposes, a theoretical ROI can be calculated based on certain assumptions made about the well and its surrounding refuse environment. The factors which influence a well's ROI include:

- the depth of the well
- the length of slotted pipe provided for gas collection
- the rate of gas generation in the refuse
- the refuse temperature
- the amount of vacuum applied to the well

The movement of landfill gas through refuse is essentially the movement of a fluid through a porous media, which can be estimated using a modified form of Darcy's equation for radial fluid flow. EIL has developed a computer spreadsheet which incorporates the Darcy equation to calculate a theoretical ROI for each well.

The designer enters the site specific information for the conceptual gas extraction system into the spreadsheet. The results allow the designer to space the gas extraction wells with an optimum amount of overlap, so that all areas of the landfill are theoretically covered. The data for the Cottonwood Hills RDF is provided in Table 3.

GENERAL ASSUMPTIONS

The careful formulation of assumptions for the spreadsheet is critical to the accuracy of the program's output, and requires some knowledge of the landfill's characteristics. While typical values are provided in the spreadsheet in a comment section, these values should only be used if no site specific information is available.

Gas Generation Rate:

Landfill gas is the by-product of the anaerobic decomposition of organic material disposed of in a landfill, by methanogenic (methane producing) bacteria. Landfill gas production is assumed to have a first order reaction rate and is dependent upon the following:

- age of the landfill
- types of waste received
- location (i.e., climate and precipitation)
- moisture conditions within the refuse
- landfill cover materials and thicknesses

EIL has an extensive landfill gas production assessment database with gas generation rates measured from over two dozen landfills during gas extraction tests conducted in the mid to late 1980s. This database is utilized to select an appropriate gas generation rate for a landfill site by selecting landfills within the database sharing similar characteristics, i.e., location (climate), type of waste stream, age, etc.

Since the Cottonwood Hills RDF is located in the midwestern United States (an area with average rainfall), only sites of similar refuse volume capacity and waste stream characterization, which have comparable precipitation amounts, were utilized to estimate a gas generation rate for the site. A rate of 0.105 cubic feet per pound of refuse per year was selected for the facility.

Permeability Factor:

Permeability is defined as a measure of the ability of a porous media to transmit fluids. While the permeability of refuse within a landfill can vary greatly, it is assumed to be a constant for ease of calculation in the spreadsheet. A reasonable absolute permeability value for refuse is 2.268×10^{-11} (ft^2). This number was calculated by EIL by applying Darcy's Law for Linear Compressible Fluid Flow to the movement of landfill gas through refuse and assuming the following:

1. Steady state flow conditions exist.
2. The pore space of the refuse is 100 percent saturated with the flowing fluid (landfill gas).
3. The viscosity of the flowing fluid is constant.
4. Isothermal conditions in the refuse prevail.
5. Flow is laminar, horizontal and linear since refuse grain size is relatively small and the velocity of fluid flow is low.

Refuse Density:

Refuse density is a function of the types of waste received and the degree of compaction at the landfill site. A refuse density of 1600 lbs/yd^3 (59.26 lbs/ft^3) was used for the calculations for the facility. However, the value can range from 29.6 lb/ft^3 to 66.76 lb/ft^3 (800 to 1800 lb/yd^3).

Gas Temperature:

The temperatures within a landfill can influence the movement of landfill gas in two ways. First, since landfill gas is a compressible fluid, its viscosity and flow characteristics must be corrected to standard temperature and pressure conditions prior to using the Darcy Equation for radial fluid flow. A discussion of this is included in Attachment 2, which presents the derivation of Darcy's equation for landfill gas flow.

Secondly, a landfill's interior temperature can affect the rate at which landfill gas is generated since different types of bacteria are present at different temperatures. Methanogens (or methane producing bacteria) that generate landfill gas at temperatures below 110°F are known as mesophilic bacteria, while those that generate gas at temperatures in excess of 110°F are called thermophilic bacteria. Although both types of bacteria produce approximately the same quality of gas, the gas generation rate is optimized in the thermophilic range.

Average Cover Depth:

The average thickness of final or intermediate cover over the waste at the time of well installation is subtracted from the refuse depth available for gas production. Soil is inert and will not contribute to the generation of landfill gas.

Average Maximum Radius of Influence:

A default maximum ROI of 175 feet was calculated for the facility, since the final cover will consist of compacted clay. If the Darcy equation calculates a radius of influence greater than 175 feet, the default maximum will be used.

Average Overlap Factor:

When the gas system designer plots the well locations on a landfill's topographic map and draws the calculated ROIs around each well, it is desirable to achieve a certain degree of overlap of the circular ROIs. Since the calculations are theoretical to begin with, the overlap provides a factor of safety to the gas control system design. If field conditions prevent gas from moving towards a particular well, an overlap helps ensure that the gas can travel to more than one collection point.

The target range of overlap values is approximately 5 to 10 percent. The overlap percentage is used in the spreadsheet's gas production rate estimate for each well, to make sure the gas volumes aren't "double counted" in areas of overlap. The overlap value used for the facility's proposed well spacing is 5%.

WELL CONSTRUCTION

Description of Vertical Gas Wells:

Typical gas wells ("slotted" or "stone column") proposed for installation at the facility are included in Appendix A. Materials of construction are indicated on the details. As indicated previously, the facility may employ a variety of collection methods in order to extract landfill gas. As-built drawings of the collection system will be kept on site in the NSPS files, as required by the regulation.

NSPS Compliance:

The proposed gas collection wells will meet the following requirements listed in 40 CFR 60.759:

- minimization of air intrusion
- waste depths and proper connector assembly (closing valves, sampling ports, etc.).
- required materials of construction and gravel dimensions
- corrosion resistance
- sufficient density of extraction devices
- avoidance of damage to underlying liners
- occurrence of water within the landfill

WM00079

TABLE 3: Radius of Influence Calculation Table

DATE: September 16, 2014
PROJ. NO:
PROJECT: Cottonwood Hills RDF - NSPS
LOCATION: Marissa, Illinois
BY: LLN

AVERAGE ASSUMPTIONS

GAS GENERATION RATE: 0.105 FT3/LBm*YR
PERMEABILITY FACTOR: 2.268 x 10E-11, FT2
REFUSE DENSITY: 59.26 LBm/FT3
GAS TEMPERATURE: 100 DEG. F
COVER DEPTH: 3 FT
DESIGN MAX. ROI: 175 FT
OVERLAP FACTOR: 5 %

Assumes standard conditions are 14.7 psia, 60 Deg. F.

WELL NO.	Well COORDINATES		SURFACE ELEVATION (FASL)	BASE ELEVATION (FASL)	DEPTH OFF BASE (FT)	LIQUID LEVEL (FASL)	WELL DEPTH (FT)	LENGTH OF PIPE		(Hs/Ht) RATIO	APPLIED VACUUM (in WC)	ROI (FT)	GAS FLOW (SCFM)
	NORTH	EAST						SOLID (FT)	SLOTTED (FT)				
MW-11RR	578143	610973	490.0	383.0	10	0	97.0	40	57	0.59	6.21	175	66.9
MW-12	578242	611277	544.0	382.0	10	0	152.0	40	112	0.74	6.21	175	102.2
MW-13R	578754	611585	574.0	384.0	10	0	180.0	40	140	0.78	6.21	175	120.2
MW-17R	578650	611246	544.0	383.0	10	0	151.0	40	111	0.74	6.21	175	101.6
MW-18	579398	611996	490.0	385.0	10	0	95.0	40	55	0.58	6.21	175	65.6
MW-19	579391	611696	538.0	386.0	10	0	142.0	40	102	0.72	6.21	175	95.8
MW-20RR	579130	611501	557.0	387.0	10	0	160.0	40	120	0.75	6.21	175	107.3
MW-21	579042	611982	543.0	387.0	10	0	146.0	40	106	0.73	6.21	175	98.3
MW-22	578907	611795	556.0	388.0	10	0	158.0	40	118	0.75	6.21	175	106.1
MW-23	577831	611227	490.0	387.0	10	0	93.0	40	53	0.57	6.21	174	63.4
MW-24	577942	611530	543.0	382.0	10	0	151.0	40	111	0.74	6.21	175	101.6
MW-25	578077	611897	562.0	383.0	10	0	169.0	40	129	0.76	6.21	175	113.1
MW-26	577568	611502	501.0	381.0	10	0	110.0	40	70	0.64	6.21	175	75.2
MW-27	577644	611789	544.0	382.0	10	0	152.0	40	112	0.74	6.21	175	102.2
MW-28	578319	611627	562.0	385.0	10	0	167.0	40	127	0.76	6.21	175	111.8
MW-29	578689	612886	480.0	382.0	10	0	88.0	40	48	0.55	6.21	170	57.7
MW-30	578589	612591	540.0	382.0	10	0	148.0	40	108	0.73	6.21	175	99.6
MW-31	578269	612476	558.0	384.0	10	0	164.0	40	124	0.76	6.21	175	109.9
MW-32	578934	612601	481.0	381.0	10	0	90.0	40	50	0.56	6.21	172	60.0
MW-33	578846	612298	540.0	382.0	10	0	148.0	40	108	0.73	6.21	175	99.6
MW-34	578742	611982	557.0	384.0	10	0	163.0	40	123	0.75	6.21	175	109.3
MW-35	578474	611887	573.0	385.0	10	0	178.0	40	138	0.78	6.21	175	118.9
MW-36	578524	612240	556.0	383.0	10	0	163.0	40	123	0.75	6.21	175	109.3
MW-37	578200	612192	573.0	385.0	10	0	178.0	40	138	0.78	6.21	175	118.9
MW-38	579182	612320	480.0	383.0	10	0	87.0	40	47	0.54	6.21	169	56.5
MW-39	577319	611789	500.0	381.0	10	0	109.0	40	69	0.63	6.21	175	74.6
MW-40	577196	612117	490.0	384.0	10	0	96.0	40	56	0.58	6.21	175	66.2
MW-41	577514	612177	545.0	382.0	10	0	153.0	40	113	0.74	6.21	175	102.8
MW-42	577832	612192	560.0	384.0	10	0	166.0	40	126	0.76	6.21	175	111.2
MW-43	577233	612483	540.0	382.0	10	0	148.0	40	108	0.73	6.21	175	99.6
MW-44	577389	612797	560.0	384.0	10	0	166.0	40	126	0.76	6.21	175	111.2
MW-45	577653	612518	559.0	383.0	10	0	166.0	40	126	0.76	6.21	175	111.2
MW-46	577962	612455	573.0	385.0	10	0	178.0	40	138	0.78	6.21	175	118.9
MW-47	576938	612341	490.0	382.0	10	0	98.0	40	58	0.59	6.21	175	67.5

WM00080

TABLE 3: Radius of Influence Calculation Table

DATE: September 16, 2014
PROJ. NO:
PROJECT: Cottonwood Hills RDF - NSPS
LOCATION: Marissa, Illinois
BY: LLN

AVERAGE ASSUMPTIONS

GAS GENERATION RATE: 0.105 FT3/LBm*YR
PERMEABILITY FACTOR: 2.268 x 10E-11, FT2
REFUSE DENSITY: 59.26 LBm/FT3
GAS TEMPERATURE: 100 DEG. F
COVER DEPTH: 3 FT
DESIGN MAX. ROI: 175 FT
OVERLAP FACTOR: 5 %
Assumes standard conditions are 14.7 psia, 60 Deg. F.

WELL NO.	Well COORDINATES NORTH	EAST	SURFACE ELEVATION (FASL)	BASE ELEVATION (FASL)	DEPTH OFF BASE (FT)	LIQUID LEVEL (FASL)	WELL DEPTH (FT)	LENGTH OF PIPE SOLID (FT)	SLOTTED (FT)	(Hs/Ht) RATIO	APPLIED VACUUM (in WC)	ROI (FT)	GAS FLOW (SCFM)
MW-48	577998	613134	544.0	383.0	10	0	151.0	40	111	0.74	6.21	175	101.6
MW-49	578037	612792	556.0	384.0	10	0	162.0	40	122	0.75	6.21	175	108.6
MW-50	577723	612900	566.0	384.0	10	0	172.0	40	132	0.77	6.21	175	115.1
MW-51	578452	613156	480.0	381.0	10	0	89.0	40	49	0.55	6.21	171	58.8
MW-52	578338	612876	540.0	383.0	10	0	147.0	40	107	0.73	6.21	175	99.0
MW-53	578185	613394	491.0	382.0	10	0	99.0	40	59	0.60	6.21	175	68.1
MW-54	576916	612674	543.0	380.0	10	0	153.0	40	113	0.74	6.21	175	102.8
MW-55	576673	612918	543.0	379.0	10	0	154.0	40	114	0.74	6.21	175	103.5
MW-56	577069	613008	561.0	381.0	10	0	170.0	40	130	0.76	6.21	175	113.8
MW-57	576698	613208	555.0	381.0	10	0	164.0	40	124	0.76	6.21	175	109.9
MW-58	576371	612797	490.0	379.0	10	0	101.0	40	61	0.60	6.21	175	69.4
MW-59	576649	612539	490.0	379.0	10	0	101.0	40	61	0.60	6.21	175	69.4
MW-60	577469	613585	498.0	379.0	10	0	109.0	40	69	0.63	6.21	175	74.6
MW-61	577621	613325	543.0	380.0	10	0	153.0	40	113	0.74	6.21	175	102.8
MW-62	577376	613118	567.0	381.0	10	0	176.0	40	136	0.77	6.21	175	117.6
MW-63	577851	613559	500.0	379.0	10	0	111.0	40	71	0.64	6.21	175	75.9
MW-64	577145	613398	540.0	381.0	10	0	149.0	40	109	0.73	6.21	175	100.3
MW-65	576992	613668	480.0	389.0	10	0	81.0	40	41	0.51	6.21	164	49.6
MW-66	576766	613449	534.0	387.0	10	0	137.0	40	97	0.71	6.21	175	92.6
MW-67	576107	613070	495.0	383.0	10	0	102.0	40	62	0.61	6.21	175	70.1
MW-68	576389	613195	543.0	384.0	10	0	149.0	40	109	0.73	6.21	175	100.3
MW-69	575829	613354	500.0	383.0	10	0	107.0	40	67	0.63	6.21	175	73.3
MW-70	575437	613643	485.0	387.0	10	0	88.0	40	48	0.55	6.21	170	57.7
MW-71	575689	613601	494.0	386.0	10	0	98.0	40	58	0.59	6.21	175	67.5
MW-72	575999	613698	470.0	387.0	10	0	73.0	37	36	0.49	5.75	156	40.7
MW-73	576105	613472	527.0	384.0	10	0	133.0	40	93	0.70	6.21	175	90.0
MW-74	576324	613702	470.0	386.0	10	0	74.0	37	37	0.50	5.75	157	41.8
MW-75	576427	613475	527.0	385.0	10	0	132.0	40	92	0.70	6.21	175	89.3
MW-76	576684	613705	470.0	387.0	10	0	73.0	37	36	0.49	5.75	156	40.7

ATTACHMENT 2
DISCUSSION OF THE
DARCY RADIUS OF INFLUENCE
FOR LANDFILL GAS EXTRACTION SYSTEMS

Purpose: To present a design procedure for determination of gas extraction well locations and relative placement/spacings.

Method: Utilization of an individual gas extraction well's Darcy radius of influence to determine well spacings to distribute an induced vacuum uniformly throughout the waste disposal area. The concept of radial fluid flow has been used in the petroleum industry for calculating flows in porous rock reservoirs towards oil and natural gas extraction wells.

Objective: As a standard design criterion, landfill gas extraction well spacing by means of the Darcy radius of influence method should indicate a reasonable effective extraction area coverage over the waste disposal area, with minimum overlap or open spaces. Placement of gas extraction wells on side slopes should be minimized to reduce air intrusion.

Definition: The radius of influence (ROI) is the radial distance from an extraction well from which the migration direction of landfill gas will be influenced by an application of vacuum. Since gas is influenced by convection forces (pressure gradient), the radius of influence is established where the measured pressure/vacuum at extreme radius (r_1) of influence is zero.

<u>Darcy radius of influence for radial compressible fluid flow</u>

Discussion: Darcy equation, for radial fluid flow

$$v = \left(\frac{g_c \cdot k}{\mu} \right) \left(\frac{dP}{dr} \right) \quad equation(1)$$

Where:

g_c	=	acceleration of gravity constant = 32.2 (lb_M-ft/lb_F-sec^2)
v	=	apparent flow velocity in (ft/sec) units
μ	=	absolute viscosity of the flowing fluid (landfill gas) in (lb_M/ft-sec) units
k	=	absolute permeability of the porous media (refuse) in (ft^2) units
dP	=	pressure gradient in the direction of radial flow in (lb_F/ft^2) units
dr	=	radial distance gradient in (ft) units

Definition: Permeability is defined as a measure of a porous media's ability to transmit fluids.

Assumptions necessary to develop the basic flow equations:

(1) steady-state flow conditions exist.
(2) the pore space of the refuse is 100 percent saturated with the flowing fluid (landfill gas).
(3) the viscosity of the flowing fluid is constant.
(4) isothermal conditions in the refuse prevail.
(5) flow is laminar, horizontal, and linear since refuse grain size is relatively small and the velocity of the fluid flow is low.

Please refer to the ideal radial flow system diagram (Figure 1). With these assumptions in mind, let

$$v = \frac{q}{A}$$

Where:	v	=	the apparent velocity of the flowing fluid (gas)
	q	=	volumetric rate of fluid (gas) flow
	A	=	total cross-sectional area perpendicular to flow direction
		=	$2\pi r h_s$
	h_s	=	total extraction well length of slotted pipe

Substitute in equation (1):

$$q / A = \left(\frac{g_C\ k}{\mu} \right) \left(\frac{dP}{dr} \right) \quad equation(2)$$

with A = $2\pi r h_s$ and rearranging

$$q = \left(\frac{2\pi\, r\, h_S\ g_C\ k}{\mu} \right) \left(\frac{dP}{dr} \right) \quad equation(3)$$

Since landfill gas is a compressible fluid, its viscosity and flow characteristics must be corrected to standard conditions.

When a flowing fluid is compressible, then q is not constant, but is a function of pressure and temperature $f(P,T)$. An expression for the standard flow rate of a gas (q_s) is obtained from Charles' law, assuming ideal gas behavior at standard conditions:

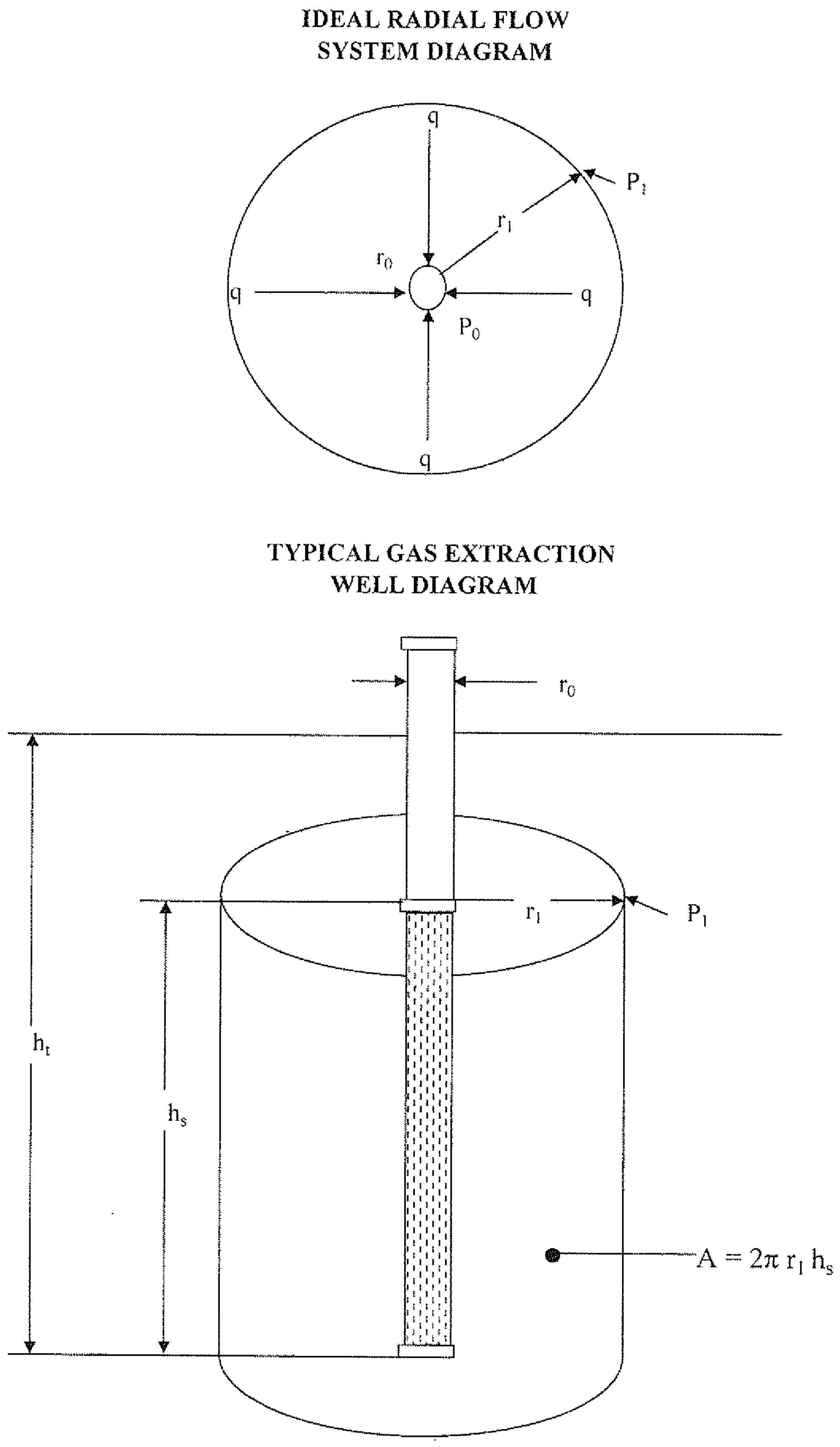

FIGURE 1: DARCY RADIUS OF INFLUENCE CONCEPTS

$$\frac{P_1 \; q_1}{T_1} = \frac{P_2 \; q_2}{T_2} = constant = \frac{P_S \; q_S}{T_S} \quad at\ standard\ conditions$$

Substitution in equation (3):

$$\frac{P_S \; q_S}{T_S} = \frac{Pq}{T} = \left(\frac{2\pi \, rh_S \; g_C \; k}{\mu \; T} \right)\left(\frac{PdP}{dr} \right) = constant$$

Where:	T_s	=	standard temperature = 60(°F) = 520(°R) constant
	P_s	=	standard pressure = 14.7 (psia) = 2,116.8 (lb_F/ft^2) constant
	T	=	flowing temperature of the fluid (landfill gas)

Therefore:

$$\frac{P_S q_S}{T_S} = \left(\frac{2\pi \, r \, h_S \, g_C \cdot k}{\mu T} \right)\left(\frac{PdP}{dr} \right) \quad equation(4)$$

let q_s = standard volumetric rate of fluid flow

$$q_S = (dG / dt) V\rho = (dG / dt) \pi r^2 h_T \rho$$

Where:	(dG/dt)	=	landfill gas generation rate
	V	=	volume of well influence, assuming uniform cylindrical geometry
	V	=	$\pi r^2 h_T$
	ρ	=	density of refuse; assume ρ = 1,200 (lb_M/yd^3) = 44.44 (lb_M/ft^3)
	h_T	=	total extraction well length (total well depth)

This approach assumes that all conditions are uniform, and that all gas generated at radius r_I is extracted. Actually, only a fraction of the gas generated at some distance "r" from the well would be extracted, and this fraction would decrease as the radius increases.

Please refer to the ideal radial flow system diagram (Figure 1).

Substitution in equation (4):

$$\frac{P_S \, (dG / dt) \, \pi r^2 \, h_T \, \rho}{T_S} = \left(\frac{2\pi \, rh_S \; g_C \; k}{\mu T} \right)\left(\frac{PdP}{dr} \right) \quad equation(5)$$

Simplification, separation of variables, and insertion of system limits in equation (5):

$$\int_{r_0}^{r_I} r\,dr = \frac{2g_C\,kT_S(h_S/h_T)}{P_S(dG/dT)\rho\mu T}\int_{P_0}^{P_I} P\,dP$$

Where: r_0 = radius of the extraction well pipe
r_I = the darcy radius of influence

Which when integrated:

$$\frac{(r_I^2 - r_0^2)}{2} = \left[\frac{g_C\;kT_S(h_S/h_T)}{P_S(dG/dt)\rho\mu T}\;x\;(P_I^2 - P_0^2)\right]$$

Solving for radius of influence (r_I):

$$r_I = \left[\frac{2g_C\;kT_S(h_S/h_T)}{P_S(dG/dt)\rho\mu T}(P_I^2 - P_0^2) + r_0^2\right]^{1/2} \qquad equation(6)$$

This is the Darcy radius of influence equation.

Since a concentric cylindrical surface at distances r_I and r_0 are assumed, perpendicular gas flow across the surface at r_I must be much greater than that across the surface at r_0 and since $r_0 \lll r_I$, then r_0 is negligible and:

$$r_I = \left[\frac{2g_C\;KT_S(h_S/h_T)}{P_S(dG/dt)\rho\mu T}(P_I^2 - P_0^2)\right]^{1/2} \qquad equation(7)$$

The maximum vacuum that can be applied in a gas extraction well is usually dependent on the length of solid pipe section specified. The relationship is that as the length of solid pipe section increases, the potential of air intrusion through the cover or side slopes decreases, therefore allowing more vacuum to be applied to the gas extraction well to maximize its effective radius of well influence. The average reasonable applied vacuum at the wellhead (P_o) for an active gas extraction system must be anticipated by the designer to calculate the Darcy radius of influence.

The following table is a guideline of reasonable applied vacuum values to be utilized in equation (7):

LENGTH OF SOLID PIPE (ft)	APPLIED VACUUM (A W.C.)	APPLIED VACUUM (lb_F / ft) absolute
15	1.0	2,111.6
20	2.0	2,106.4
25	3.0	2,101.2
30	4.0	2,096.0
35	5.0	2,090.8
40	6.0	2,085.6

The following calculation demonstrates how the Darcy radius of influence can be determined for a conceptual gas extraction well location plan.

Assumptions:

Average landfill gas composition:

percent methane (CH_4)	=	56 %
percent carbon dioxide (CO_2)	=	43 %
percent air (N_2/O_2)	=	1 %
Total	=	100 %

Average flowing landfill gas temperature *(T)* = 86(°F) = 546(°R)

Average reasonable gas generation rate *(dG/dt)* = $0.102(ft^3/lb_M{-}yr)$

or *(dG/dt)* = $3.234 \times 10^{-9}(ft^3/lb_M{-}sec)$

Average reasonable applied vacuum at the wellhead (P_o) for an active gas extraction system with a 29-foot length of solid pipe:

P_o = 3.8 (inches of water column)

= 0.137 (psig)

= 2.097.0 (lb_F/ft^2) absolute

Conversion: 1.0 (psig) = 27.7 (inches of water column)

Average reasonable absolute permeability of refuse *(k)*.

$k = 2.681 \times 10^{-11}(ft^2)$

Typical gas absolute viscosity at standard temperature conditions = 60(°F)

Absolute Viscosity Reference Values

methane (CH_4) = 7.1×10^{-6} (lb_M/ft–sec)

carbon dioxide (CO_2) = 9.8×10^{-6} (lb_M/ft–sec)

air (N_2/O_2) = 1.2×10^{-5} (lb_M/ft–sec)

Standard landfill gas viscosity (μ) at 60(°F):

$$\mu = (0.56)(7.1 \times 10^{-6}) + (0.43)(9.8 \times 10^{-6}) + (0.01)(1.2 \times 10^{-5})$$

$$\mu = 8.31 \times 10^{-6} \text{ } (lb_M/ft\text{–}sec)$$

Determine the ratio of slotted pipe to total pipe section for typical gas extraction wells as specified by the designer.

Typical ratio value (h_s / h_T) = 0.567, approximately two-thirds slotted length per total length.

Constants utilized in the darcy radius of well influence, equation (7):

g_c = acceleration of gravity constant = 32.2 32.2 (lb_M–ft / lb_F –sec^2)
T_s = standard temperature = 520 (°R)
P_s = standard pressure = 2,116.8 (lb_F/ft^2)
ρ = density of refuse = 44.44 (lb_M/ft^3)
P_I = pressure/vacuum at extreme radius (r_I) of influence convention pressure gradient
P_I = 0 (inches of water column)
P_I = 0 (psig) = 14.7 (psia) absolute
P_I = 2,116.8 (lb_F/ft^2) absolute

Note that $P_I = P_s$ = 2,116.8 (lb_F/ft^2) absolute atmospheric pressure.
Substitute in equation (7) to derive the darcy radius of influence for a typical gas extraction well.

$$r_I = \left[\frac{(2 \times 32.2)(2.681 \times 10^{-11})(520)(0.567)[(2,116.7)^2 - (2,097.0)^2]}{(2,116.8)(3.234 \times 10^{-9})(44.44)(8.31 \times 10^{-6})(546)} \right]^{1/2}$$

$$r_I = \left[3.077 \times 10^4 (ft^2) \right]^{1/2}$$

Therefore: r_I = 175.4 (ft) = 175 (ft) radius of well influence.

HEADER PIPE SIZING

INTRODUCTION

The next step in designing a gas collection system is to lay out a routing for the header line and laterals to connect each of the gas wells into the system, and convey the collected gas to a central location for destruction. After the design engineer has routed the most efficient header system for collecting gas from the extraction wells, the header pipe must be sized appropriately to convey the maximum expected gas flow [40 CFR §60.752(b)(2)(ii)(A)(1)]. Typical design criteria and header construction methods are generally discussed in the following subsections.

The Cottonwood Hills RDF has an existing gas collection system over a portion of the waste. The following provides a narrative describing the results of a KYGas® analysis of the landfill gas collection and control system (GCCS) installed at the facility. The purpose of conducting this analysis was to determine the required piping size for the future system in order to convey the maximum expected gas flow rate.

The KYGas® model was development by the University of Kentucky for performing water and gas distribution flow analyses. The program uses a 2-dimensional model depicting the geometry of the piping system. Once the 2-dimension layout of the system has been entered into the model, the user enters the physical properties of the gas, plus other site-specific parameters for the size and type of pipe, gas flow requirements, and operating pressure conditions to calculate the system gas velocities and pressure distribution.

KYGas® utilizes the Ideal Gas Law for pressure-temperature-density relationships and the Darcy-Weisbach equation for head losses related to uncompressible flow. The program operates under the assumption that all flow in the piping system is steady, one-dimensional, isothermal flow for an ideal gas.

MODEL INPUT DATA

For the Cottonwood Hills RDF, the GCCS layout and pipe sizes used in the model were based on as-built information provided for the existing system, and the proposed future expansions of the system through site closure. High density polyethylene (HDPE) piping having a standard diameter ratio (SDR) rating of 17 was assumed for the inside pipe diameters. Other parameters required for the model include:

- Pipe length
- Roughness within the pipe
- Minor loss coefficient
- LFG operating temperature (assumed to be 110 °F)
- LFG flow rate into the system at each well or node
- Ratio of specific heats (1.303)
- Specific gravity of the landfill gas (1.036)
- Absolute viscosity of the landfill gas (2.82×10^{-7} lb*sec/ft^2)

The peak landfill gas (LFG) flow rate condition used in the model was derived by summing up the individual expected flows from each future well from the ROI spreadsheet, as well as the average actual well flows from sixteen of the existing wells. This flow volume totaled up to 6565.3 cfm, which nearly matches the maximum modeled gas flow rate of 6,522 cfm. AP-42 assumes that a facility can achieve an average collection efficiency of 75%.

The gas extraction flow rates used in the model for the future extraction wells (including planned replacements for existing wells) were obtained directly from the ROI spreadsheet. Gas flow rates from the existing wells were averaged from actual data.

The KYGas® model requires the user to specify an operating pressure for each vacuum source used in the analysis. A target vacuum of 100 inches water column gauge ("w.c.) was used during the KYGas® analysis for the blower at the proposed flare station, based on the calculations in the next section. The existing blower is adequately sized for the existing system. Blowers will be frequently upsized and exchanged as the gas collection system is expanded, so a second 100"w.c. blower was added to the model at the existing flare station to simulate this future upgrade.

The user can start the evaluation of the system once all of the required information is input into the program. This evaluation is an iterative process. Multiple model runs are conducted by adjusting the pipe diameter, until the velocities in the system piping and the vacuum pressure remaining at the furthest node meet design requirements.

The design criteria utilized for the header system is as follows:

- Maximum velocity: 40 feet/second
- Maximum pressure drop: 1 inch per 100 feet of pipe
- Minimum vacuum at any node/well: 10 inches of water column

DESCRIPTION OF KYGAS® MODEL RESULTS

A copy of the KYGas® model print out for the Cottonwood Hills RDF is provided as Attachment 3. Also included are three model-generated layouts of the GCCS. Figure 1 identifies the pipe segment and pipe node names used by the model. These names can be used to reference the information on the model print-out. Figure 2 shows the pipe sizes used, and Figure 3 shows the available vacuum at each well, and the calculated flow rate through each pipe segment.

A summary of the simulation is provided, including gas parameters and units of measure. The geometry and operating criteria used in the model is identified, including pipe names, nodes that connect to each pipe segment, pipe lengths and diameters, and pipe roughness.

The next set of pages summarizes the junction "nodes" and their "demand", or the unit flow rate for the quantity of LFG entering the system at that node location. Because the GCCS operates under a negative pressure, the operating flow rates and pressures are entered as negative numbers. Column 3 indicates the LFG extraction flow rate that is introduced to the piping system at that junction location.

The modeling results for each pipe segment are then provided. This includes the calculated LFG flow rate through each pipe segment. A negative number indicates the direction of LFG flow is reversed from the orientation indicated by the pipe nodes. Also shown is the calculated friction loss along the length of pipe segment expressed in inches of water column, the calculated velocity of the LFG flowing through the pipe segment, the density of LFG used in the calculations, and a variable calculated by the model for each pipe segment based on flow rate.

SUMMARY OF KYGAS® RESULTS

The KYGas® results for the Cottonwood Hills RDF indicate that all values are within the specified design criteria. Therefore, the pipe sizing selected meets the NSPS requirement to convey the maximum expected gas flow rate.

HEADER CONSTRUCTION

Description of Header Collection Pipe Network

The header pipe proposed for installation is high density polyethylene (HDPE) pipe. HDPE pipe is ideal due to its compatibility with landfill gas and waste, its flexibility (if settlement occurs), its long term stability and its excellent chemical resistance. The pipe is set in a trench, and is surrounded by compatible bedding media.

Control valves are located throughout the collection header network. The valves can manually shut off the applied vacuum to a particular section of header pipe. This allows portions of the well field to be isolated for monitoring and maintenance purposes.

NSPS Compliance

Blind flanges have been incorporated into the design in order to allow for future gas system expansions. The header system as described in this section will meet the following requirements listed in 40 CFR §60.759:

- gas system expandability & accessibility
- corrosion resistance
- fill settlement
- required materials of construction
- ability to withstand planned overburden or traffic loads

ATTACHMENT 3

KYGas® MODEL RESULTS

```
* * * * * * * * * * * * * * K Y G A S * * * * * * * * * * * * * *
*                                                                 *
*  Gas Network Analysis Software                                  *
*                                                                 *
*  CopyRighted by KYPIPE LLC (www.kypipe.com)                     *
*  Version: 6.025  10/21/2013                                     *
*  Company:  Environmen    Serial #:  1                           *
*  Interface:  Classic                                            *
*  Licensed for Pipe2006                                          *
*                                                                 *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

INPUT DATA FILE NAME FOR THIS SIMULATION = c:\eil\EILPRO~1\WASTEM~1\COTTON~1\2014\CO5C79~1.KYP\cottonwo.DAT
OUTPUT DATA FILE NAME FOR THIS SIMULATION = c:\eil\EILPRO~1\WASTEM~1\COTTON~1\2014\CO5C79~1.KYP\cottonwo.OT2

DATE FOR THIS COMPUTER RUN   : 9-18-2014
START TIME FOR THIS COMPUTER RUN : 15:15:14:65

SUMMARY OF DISTRIBUTION SYSTEM CHARACTERISTICS:

NUMBER OF PIPES   =   136
NUMBER OF JUNCTION NODES =   129

UNITS SPECIFIED   = ENGLISH

A CONSTANT DENSITY FLUID IS SPECIFIED - DENSITY =   .08POUNDS/CUBIC FOOT
ABSOLUTE VISCOSITY   =   .230E-06 POUND SECONDS/SQUARE FOOT

USER SPEC. FLOW UNITS (USFU)   = SCF / MIN.
USER SPEC. PRESSURE UNITS(USPU) = INCHES OF WATER (GAUGE)

------- SUMMARY OF PIPE NETWORK GEOMETRIC AND OPERATING DATA -------

PIPE NAME	NODE #1	NODE #2	LENGTH (FT.)	DIAM. (IN.)	ROUGHNESS (MILLIFEET)	SUM-M FACT.	PUMP ID	ELEVATION CHANGE
P-1	J-2	J-28	435.0	19.3	.400	.0	0	.0
P-10	J-16	MW01	336.0	21.0	.400	.0	0	.0
P-100	MW55	J-92	225.0	7.6	.400	.0	0	.0
P-101	J-95	MW55	50.0	7.6	.400	.0	0	.0
P-102	J-95	MW56	392.0	5.8	.400	.0	0	.0
P-103	MW57	J-95	239.0	7.6	.400	.0	0	.0
P-104	MW66	MW57	248.0	7.6	.400	.0	0	.0
P-105	MW65	J-100	180.0	15.8	.400	.0	0	.0
P-106	J-100	MW66	279.0	7.6	.400	.0	0	.0
P-107	J-100	MW76	131.0	15.8	.400	.0	0	.0
P-108	MW74	MW75	250.0	5.8	.400	.0	0	.0
P-109	J-103	J-38	407.0	15.8	.400	.0	0	.0
P-11	J-21	J-68	142.0	15.8	.400	.0	0	.0
P-110	J-103	J-104	391.0	15.8	.400	.0	0	.0

------- SUMMARY OF PIPE NETWORK GEOMETRIC AND OPERATING DATA -------

PIPE NAME	NODE #1	NODE #2	LENGTH (FT.)	DIAM. (IN.)	ROUGHNESS (MILLIFEET)	SUM-M FACT.	PUMP ID	ELEVATION CHANGE
P-111	J-104	MW58	58.0	5.8	.400	.0	0	.0
P-112	J-104	MW67	386.0	15.8	.400	.0	0	.0
P-113	MW67	MW68	328.0	5.8	.400	.0	0	.0
P-114	MW67	MW69	390.0	15.8	.400	.0	0	.0
P-115	J-108	MW70	23.0	5.8	.400	.0	0	.0
P-116	J-108	J-111	373.0	15.8	.400	.0	0	.0
P-117	J-111	MW71	116.0	5.8	.400	.0	0	.0
P-118	J-111	J-115	315.0	15.8	.400	.0	0	.0
P-119	MW72	MW73	249.0	5.8	.400	.0	0	.0
P-12	J-1aProposed		121.0	21.0	.400	.0	0	.0
P-120	MW69	J-108	485.0	15.8	.400	.0	0	.0
P-121	J-115	MW72	55.0	5.8	.400	.0	0	.0
P-122	J-115	J-117	359.0	15.8	.400	.0	0	.0
P-123	J-117	MW74	96.0	5.8	.400	.0	0	.0
P-124	MW76	J-117	352.0	15.8	.400	.0	0	.0
P-125	MW63	J-84	193.0	15.8	.400	.0	0	.0
P-126	J-18	MW28	71.0	5.8	.400	.0	0	.0
P-127	MW08	J-24	64.0	7.6	.400	.0	0	.0
P-128	MW02	MW07R1	314.0	7.6	.400	.0	0	.0
P-129	MW07R1	MW81	196.0	7.6	.400	.0	0	.0
P-13	MW01	J-1	396.0	21.0	.400	.0	0	.0
P-130	J-3	MW09R	84.0	5.8	.400	.0	0	.0
P-131	J-3	MW19	146.0	7.6	.400	.0	0	.0
P-132	J-5	MW77	66.0	5.8	.400	.0	0	.0
P-134	MW19	J-5	193.0	7.6	.400	.0	0	.0
P-135	MW20RR	J-23	427.0	7.6	.400	.0	0	.0
P-137	J-6	MW17R	299.0	5.8	.400	.0	0	.0
P-14	MW18	MW79R	335.0	7.6	.400	.0	0	.0
P-147	J-6	MW11RR	308.0	7.6	.400	.0	0	.0
P-15	MW79R	MW20RR	229.0	7.6	.400	.0	0	.0
P-16	J-16	MW18	80.0	7.6	.400	.0	0	.0
P-17	J-16	J-17	161.0	15.8	.400	.0	0	.0
P-18	J-17	MW21	339.0	5.8	.400	.0	0	.0
P-19	J-17	J-19	221.0	15.8	.400	.0	0	.0
P-2	J-2	MW04	37.0	7.6	.400	.0	0	.0
P-20	J-19	MW38	43.0	5.8	.400	.0	0	.0
P-21	J-19	J-21	229.0	15.8	.400	.0	0	.0
P-22	MW21	MW22	232.0	5.8	.400	.0	0	.0
P-23	J-23	MW08	82.0	7.6	.400	.0	0	.0
P-24	MW14R	J-23	240.0	5.8	.400	.0	0	.0
P-25	J-24	J-33	386.0	19.3	.400	.0	0	.0
P-26	J-24	J-26	362.0	19.3	.400	.0	0	.0
P-27	J-26	MW06	26.0	7.6	.400	.0	0	.0
P-28	J-26	J-28	434.0	19.3	.400	.0	0	.0
P-29	J-28	MW05	31.0	5.8	.400	.0	0	.0
P-3	J-7	J-4	447.0	19.3	.400	.0	0	.0
P-30	MW17R	MW13R	358.0	5.8	.400	.0	0	.0
P-31	J-1	R-2	192.0	19.3	.400	.0	0	.0
P-33	MW06	MW10R	261.0	7.6	.400	.0	0	.0
P-34	J-33	MW15	33.0	5.8	.400	.0	0	.0
P-35	J-33	J-36	387.0	21.0	.400	.0	0	.0
P-36	MW16	J-6	67.0	7.6	.400	.0	0	.0

------- SUMMARY OF PIPE NETWORK GEOMETRIC AND OPERATING DATA -------

WM00093

PIPE NAME	NODE #1	NODE #2	LENGTH (FT.)	DIAM. (IN.)	ROUGHNESS (MILLIFEET)	SUM-M FACT.	PUMP ID	ELEVATION CHANGE
P-37	J-36	MW16	170.0	7.6	.400	.0	0	.0
P-38	J-36	J-37	439.0	15.8	.400	.0	0	.0
P-39	J-37	J-44	398.0	15.8	.400	.0	0	.0
P-4	J-4	MW03R	25.0	7.6	.400	.0	0	.0
P-40	J-37	MW11RR	86.0	11.3	.400	.0	0	.0
P-41	MW11RR	MW12	324.0	11.3	.400	.0	0	.0
P-42	MW24	MW25	391.0	5.8	.400	.0	0	.0
P-43	MW23	MW24	317.0	5.8	.400	.0	0	.0
P-44	MW12	J-18	298.0	11.3	.400	.0	0	.0
P-45	J-44	MW23	34.0	5.8	.400	.0	0	.0
P-46	J-44	J-48	381.0	15.8	.400	.0	0	.0
P-47	J-45	J-50	241.0	15.8	.400	.0	0	.0
P-48	J-45	MW27	274.0	5.8	.400	.0	0	.0
P-49	J-48	J-45	159.0	15.8	.400	.0	0	.0
P-5	J-4	J-2	276.0	19.3	.400	.0	0	.0
P-50	J-48	MW26	32.0	5.8	.400	.0	0	.0
P-51	J-50	MW39	30.0	5.8	.400	.0	0	.0
P-52	J-50	J-91	355.0	15.8	.400	.0	0	.0
P-53	J-51	MW50	191.0	5.8	.400	.0	0	.0
P-54	J-51	J-54	132.0	7.6	.400	.0	0	.0
P-55	J-54	J-57	126.0	7.6	.400	.0	0	.0
P-56	J-54	MW49	232.0	5.8	.400	.0	0	.0
P-57	MW49	MW46	342.0	5.8	.400	.0	0	.0
P-58	J-57	MW48	44.0	5.8	.400	.0	0	.0
P-59	J-57	MW53	310.0	7.6	.400	.0	0	.0
P-6	J-7	MW02	114.0	7.6	.400	.0	0	.0
P-60	MW53	J-61	34.0	9.5	.400	.0	0	.0
P-61	MW40	J-77	122.0	7.6	.400	.0	0	.0
P-62	J-61	MW63	427.0	15.8	.400	.0	0	.0
P-63	J-61	J-64	357.0	15.8	.400	.0	0	.0
P-64	MW51	MW52	301.0	5.8	.400	.0	0	.0
P-65	J-64	MW51	35.0	5.8	.400	.0	0	.0
P-66	J-64	J-67	364.0	15.8	.400	.0	0	.0
P-67	MW29	MW30	310.0	5.8	.400	.0	0	.0
P-68	J-67	MW29	81.0	5.8	.400	.0	0	.0
P-69	J-67	J-1a	263.0	15.8	.400	.0	0	.0
P-7	J-1a	J-68	113.0	15.8	.400	.0	0	.0
P-71	J-68	MW32	95.0	5.8	.400	.0	0	.0
P-72	J-21	MW33	343.0	11.3	.400	.0	0	.0
P-73	J-70	J-74	69.0	11.3	.400	.0	0	.0
P-74	J-70	MW36	245.0	5.8	.400	.0	0	.0
P-75	MW33	J-70	120.0	11.3	.400	.0	0	.0
P-76	J-74	MW34	179.0	5.8	.400	.0	0	.0
P-77	J-74	MW35	365.0	11.3	.400	.0	0	.0
P-78	MW30	MW31	343.0	5.8	.400	.0	0	.0
P-79	MW36	MW37	336.0	5.8	.400	.0	0	.0
P-8	MW01	J-3	297.0	19.3	.400	.0	0	.0
P-80	J-18	MW35	362.0	11.3	.400	.0	0	.0
P-81	MW45	J-51	463.0	7.6	.400	.0	0	.0
P-82	J-77	J-80	23.0	7.6	.400	.0	0	.0
P-83	J-77	MW41	221.0	5.8	.400	.0	0	.0
P-84	MW41	MW42	312.0	5.8	.400	.0	0	.0

------- SUMMARY OF PIPE NETWORK GEOMETRIC AND OPERATING DATA -------

PIPE NAME	NODE #1	NODE #2	LENGTH (FT.)	DIAM. (IN.)	ROUGHNESS (MILLIFEET)	SUM-M FACT.	PUMP ID	ELEVATION CHANGE
P-85	J-80	MW45	462.0	7.6	.400	.0	0	.0
P-86	J-80	MW43	298.0	5.8	.400	.0	0	.0
P-87	MW43	MW44	349.0	5.8	.400	.0	0	.0
P-88	MW61	MW62	323.0	5.8	.400	.0	0	.0
P-89	J-84	MW61	254.0	5.8	.400	.0	0	.0
P-9	J-1	J-7	17.0	19.3	.400	.0	0	.0
P-90	J-84	MW60	194.0	15.8	.400	.0	0	.0
P-91	MW60	J-87	287.0	15.8	.400	.0	0	.0
P-92	J-87	MW64	261.0	5.8	.400	.0	0	.0
P-93	J-87	MW65	192.0	15.8	.400	.0	0	.0
P-94	J-88	MW47	82.0	5.8	.400	.0	0	.0
P-95	J-88	J-91	329.0	15.8	.400	.0	0	.0
P-96	J-91	MW40	42.0	7.6	.400	.0	0	.0
P-97	MW59	J-103	109.0	7.6	.400	.0	0	.0
P-98	J-92	MW59	154.0	7.6	.400	.0	0	.0
P-99	J-92	MW54	258.0	5.8	.400	.0	0	.0

JUNCTION NAME	NODE TITLE	ELEV	DEMAND (USFU)	FPN PRESSURE
J-1		.00	.00	
J-100		.00	.00	
J-103		.00	.00	
J-104		.00	.00	
J-108		.00	.00	
J-111		.00	.00	
J-115		.00	.00	
J-117		.00	.00	
J-16		.00	.00	
J-17		.00	.00	
J-18		.00	.00	
J-19		.00	.00	
J-1a		.00	.00	
J-2		.00	.00	
J-21		.00	.00	
J-23		.00	.00	
J-24		.00	.00	
J-26		.00	.00	
J-28		.00	.00	
J-3		.00	.00	
J-33		.00	.00	
J-36		.00	.00	
J-37		.00	.00	
J-4		.00	.00	
J-44		.00	.00	
J-45		.00	.00	
J-48		.00	.00	
J-5		.00	.00	
J-50		.00	.00	
J-51		.00	.00	
J-54		.00	.00	

JUNCTION NODE ELEV DEMAND FPN

JUNCTION NAME	NODE TITLE	ELEV	DEMAND (USFU)	FPN PRESSURE
J-57		.00	.00	
J-6		.00	.00	
J-61		.00	.00	
J-64		.00	.00	
J-67		.00	.00	
J-68		.00	.00	
J-7		.00	.00	
J-70		.00	.00	
J-74		.00	.00	
J-77		.00	.00	
J-80		.00	.00	
J-84		.00	.00	
J-87		.00	.00	
J-88		.00	.00	
J-91		.00	.00	
J-92		.00	.00	
J-95		.00	.00	
MW01		.00	-66.00	
MW02		.00	-97.00	
MW03R		.00	-27.00	
MW04		.00	-78.00	
MW05		.00	-40.00	
MW06		.00	-63.00	
MW07R1		.00	-16.00	
MW08		.00	-78.00	
MW09R		.00	-90.00	
MW10R		.00	-99.00	
MW11RR		.00	-66.90	
MW12		.00	-102.20	
MW13R		.00	-120.20	
MW14R		.00	-22.00	
MW15		.00	-44.00	
MW16		.00	-46.00	
MW17R		.00	-101.60	
MW18		.00	-65.60	
MW19		.00	-95.80	
MW20RR		.00	-107.30	
MW21		.00	-98.30	
MW22		.00	-106.10	
MW23		.00	-63.40	
MW24		.00	-101.60	
MW25		.00	-113.10	
MW26		.00	-75.20	
MW27		.00	-102.20	
MW28		.00	-111.80	
MW29		.00	-57.70	
MW30		.00	-99.60	
MW31		.00	-109.90	
MW32		.00	-60.00	
MW33		.00	-99.60	
MW34		.00	-109.30	
MW35		.00	-118.90	
MW36		.00	-109.30	

NAME	TITLE		(USFU)	PRESSURE
MW37		.00	-118.90	
MW38		.00	-56.50	
MW39		.00	-74.60	
MW40		.00	-66.20	
MW41		.00	-102.80	
MW42		.00	-111.20	
MW43		.00	-99.60	
MW44		.00	-111.20	
MW45		.00	-111.20	
MW46		.00	-118.90	
MW47		.00	-67.50	
MW48		.00	-101.60	
MW49		.00	-108.60	
MW50		.00	-115.10	
MW51		.00	-58.80	
MW52		.00	-99.00	
MW53		.00	-68.10	
MW54		.00	-102.80	
MW55		.00	-103.50	
MW56		.00	-113.80	
MW57		.00	-109.90	
MW58		.00	-69.40	
MW59		.00	-69.40	
MW60		.00	-74.60	
MW61		.00	-102.80	
MW62		.00	-117.60	
MW63		.00	-75.90	
MW64		.00	-100.30	
MW65		.00	-49.60	
MW66		.00	-92.60	
MW67		.00	-70.10	
MW68		.00	-100.30	
MW69		.00	-73.30	
MW70		.00	-57.70	
MW71		.00	-67.50	
MW72		.00	-40.70	
MW73		.00	-90.00	
MW74		.00	-41.80	
MW75		.00	-89.30	
MW76		.00	-40.70	
MW77		.00	-36.00	
MW79R		.00	-99.30	
MW81		.00	-25.00	
Proposed		.00	.00	-100.00
R-2		.00	.00	-100.00

Set = 0

==================== RESULTS FOR THIS SIMULATION FOLLOW ================

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Solution was obtained in   23 trials
 Flow Accuracy =  .2055E-02[ <  .500E-02]
   RV Accuracy =  .0000E+00[ <  .100E-02]
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PIPE NO.	NODE #1	NODE #2	FLOW (USFU)	LOSS (USPU)	VELOCITY (FT/S)	DENSITY (#/CF)	FRICTION FACTOR	AREA RATIO
P-1	J-2	J-28	-1933.671	.27	16.25	.075	.0169	
P-10	J-16	MW01	518.723	.01	3.66	.075	.0206	
P-100	MW55	J-92	138.601	.10	7.45	.075	.0232	
P-101	J-95	MW55	35.101	.00	1.89	.075	.0304	
P-102	J-95	MW56	-113.800	.46	10.33	.075	.0236	
P-103	MW57	J-95	-78.699	.04	4.23	.075	.0257	
P-104	MW66	MW57	-188.599	.20	10.14	.075	.0222	
P-105	MW65	J-100	-920.161	.08	11.55	.075	.0184	
P-106	J-100	MW66	-281.199	.47	15.12	.075	.0210	
P-107	J-100	MW76	-638.962	.03	8.02	.075	.0193	
P-108	MW74	MW75	-89.300	.19	8.14	.075	.0244	
P-109	J-103	J-88	412.639	.04	5.18	.075	.0207	
P-11	J-21	J-68	1097.738	.08	13.78	.075	.0180	
P-110	J-103	J-104	-101.838	.00	1.28	.075	.0278	
P-111	J-104	MW58	-69.400	.03	6.33	.075	.0255	
P-112	J-104	MW67	-32.438	.00	.41	.075	.0385	
P-113	MW67	MW68	-100.300	.30	9.15	.075	.0240	
P-114	MW67	MW69	137.962	.01	1.73	.075	.0256	
P-115	J-108	MW70	-57.700	.01	5.26	.075	.0264	
P-116	J-108	J-111	268.962	.02	3.38	.075	.0223	
P-117	J-111	MW71	-67.500	.05	6.16	.075	.0256	
P-118	J-111	J-115	336.462	.02	4.22	.075	.0214	
P-119	MW72	MW73	-90.000	.19	8.21	.075	.0244	
P-12	J-1aProposed		3582.106	.16	25.29	.075	.0159	
P-120	MW69	J-108	211.262	.01	2.65	.075	.0234	
P-121	J-115	MW72	-130.700	.08	11.92	.075	.0231	
P-122	J-115	J-117	467.162	.04	5.86	.075	.0203	
P-123	J-117	MW74	-131.100	.15	11.96	.075	.0231	
P-124	MW76	J-117	-598.262	.07	7.51	.075	.0195	
P-125	MW63	J-84	-1365.061	.17	17.13	.075	.0176	
P-126	J-18	MW28	-111.800	.08	10.20	.075	.0236	
P-127	MW08	J-24	6.603	.00	.36	.075	.0341	
P-128	MW02	MW07R1	-41.000	.02	2.21	.075	.0295	
P-129	MW07R1	MW81	-25.000	.00	1.34	.075	.0333	
P-13	MW01	J-1	806.523	.03	5.69	.075	.0191	
P-130	J-3	MW09R	-90.000	.06	8.21	.075	.0244	
P-131	J-3	MW19	-131.800	.06	7.09	.075	.0234	
P-132	J-5	MW77	-36.000	.01	3.28	.075	.0290	
P-134	MW19	J-5	-36.000	.01	1.94	.075	.0304	
P-135	MW20RR	J-23	-93.397	.09	5.02	.075	.0248	

PIPE NO.	NODE #1	NODE #2	FLOW (USFU)	LOSS (USPU)	VELOCITY (FT/S)	DENSITY (#/CF)	FRICTION FACTOR	AREA RATIO
P-137	J-6	MW17R	-221.800	1.22	20.23	.075	.0217	
P-14	MW18	MW79R	-299.997	.64	16.14	.075	.0209	

P-147	J-6	MW11RR	-20.298	.00	1.09	.075	.0349	
P-15	MW79R	MW20RR	-200.697	.21	10.79	.075	.0219	
P-16	J-16	MW18	-365.597	.22	19.66	.075	.0204	
P-17	J-16	J-17	-153.126	.00	1.92	.075	.0251	
P-18	J-17	MW21	-204.400	1.19	18.64	.075	.0219	
P-19	J-17	J-19	51.274	.00	.64	.075	.0329	
P-2	J-2	MW04	-78.000	.01	4.20	.075	.0257	
P-20	J-19	MW38	-56.500	.01	5.15	.075	.0265	
P-21	J-19	J-21	107.774	.00	1.35	.075	.0272	
P-22	MW21	MW22	-106.100	.24	9.68	.075	.0238	
P-23	J-23	MW08	-71.397	.01	3.84	.075	.0260	
P-24	MW14R	J-23	22.000	.01	2.01	.075	.0324	
P-25	J-24	J-33	-1725.068	.19	14.49	.075	.0171	
P-26	J-24	J-26	1731.671	.18	14.55	.075	.0171	
P-27	J-26	MW06	-162.000	.02	8.71	.075	.0227	
P-28	J-26	J-28	1893.671	.26	15.91	.075	.0170	
P-29	J-28	MW05	-40.000	.01	3.65	.075	.0283	
P-3	J-7	J-4	-2038.670	.31	17.13	.075	.0168	
P-30	MW17R	MW13R	-120.200	.46	10.96	.075	.0234	
P-31	J-1	R-2	2983.194	.27	25.06	.075	.0162	
P-33	MW06	MW10R	-99.000	.06	5.32	.075	.0246	
P-34	J-33	MW15	-44.000	.01	4.01	.075	.0278	
P-35	J-33	J-36	-1681.068	.12	11.87	.075	.0172	
P-36	MW16	J-6	-242.098	.09	13.02	.075	.0214	
P-37	J-36	MW16	-288.098	.30	15.50	.075	.0210	
P-38	J-36	J-37	-1392.970	.40	17.49	.075	.0175	
P-39	J-37	J-44	-1566.331	.45	19.66	.075	.0173	
P-4	J-4	MW03R	-27.000	.00	1.45	.075	.0326	
P-40	J-37	MW11RR	173.361	.01	4.27	.075	.0232	
P-41	MW11RR	MW12	219.963	.05	5.42	.075	.0223	
P-42	MW24	MW25	-113.100	.45	10.31	.075	.0236	
P-43	MW23	MW24	-214.700	1.22	19.58	.075	.0218	
P-44	MW12	J-18	322.163	.09	7.93	.075	.0209	
P-45	J-44	MW23	-278.100	.21	25.36	.075	.0212	
P-46	J-44	J-48	-1288.231	.30	16.17	.075	.0177	
P-47	J-45	J-50	-1110.831	.14	13.94	.075	.0180	
P-48	J-45	MW27	-102.200	.26	9.32	.075	.0239	
P-49	J-48	J-45	-1213.031	.11	15.23	.075	.0178	
P-5	J-4	J-2	-2011.671	.19	16.90	.075	.0168	
P-50	J-48	MW26	-75.200	.02	6.86	.075	.0251	
P-51	J-50	MW39	-74.600	.02	6.80	.075	.0252	
P-52	J-50	J-91	-1036.231	.19	13.01	.075	.0181	
P-53	J-51	MW50	-115.100	.23	10.50	.075	.0235	
P-54	J-51	J-54	161.208	.08	8.67	.075	.0227	
P-55	J-54	J-57	388.708	.40	20.91	.075	.0203	
P-56	J-54	MW49	-227.500	.99	20.75	.075	.0216	
P-57	MW49	MW46	-118.900	.43	10.84	.075	.0234	

PIPE NO.	NODE #1	NODE #2	FLOW (USFU)	LOSS (USPU)	VELOCITY (FT/S)	DENSITY (#/CF)	FRICTION FACTOR	AREA RATIO
P-58	J-57	MW48	-101.600	.04	9.27	.075	.0240	
P-59	J-57	MW53	490.308	1.51	26.37	.075	.0199	
P-6	J-7	MW02	-138.000	.05	7.42	.075	.0232	
P-60	MW53	J-61	558.408	.07	19.34	.075	.0194	
P-61	MW40	J-77	-489.892	.59	26.35	.075	.0199	

P-62	J-61	MW63	-1440.961	.42	18.09	.075	.0175
P-63	J-61	J-64	1999.369	.65	25.10	.075	.0169
P-64	MW51	MW52	-99.000	.27	9.03	.075	.0241
P-65	J-64	MW51	-157.800	.08	14.39	.075	.0226
P-66	J-64	J-67	2157.169	.77	27.08	.075	.0168
P-67	MW29	MW30	-209.500	1.14	19.11	.075	.0218
P-68	J-67	MW29	-267.200	.47	24.37	.075	.0213
P-69	J-67	J-1a	2424.369	.69	30.43	.075	.0167
P-7	J-1a	J-68	-1157.738	.08	14.53	.075	.0179
P-71	J-68	MW32	-60.000	.03	5.47	.075	.0262
P-72	J-21	MW33	-989.963	.89	24.37	.075	.0183
P-73	J-70	J-74	-662.163	.08	16.30	.075	.0190
P-74	J-70	MW36	-228.200	1.06	20.81	.075	.0216
P-75	MW33	J-70	-890.363	.25	21.92	.075	.0185
P-76	J-74	MW34	-109.300	.19	9.97	.075	.0237
P-77	J-74	MW35	-552.863	.31	13.61	.075	.0194
P-78	MW30	MW31	-109.900	.38	10.02	.075	.0237
P-79	MW36	MW37	-118.900	.43	10.84	.075	.0234
P-8	MW01	J-3	-221.800	.00	1.86	.075	.0241
P-80	J-18	MW35	433.963	.20	10.68	.075	.0201
P-81	MW45	J-51	46.108	.03	2.48	.075	.0288
P-82	J-77	J-80	-275.892	.04	14.84	.075	.0211
P-83	J-77	MW41	-214.000	.84	19.52	.075	.0218
P-84	MW41	MW42	-111.200	.35	10.14	.075	.0236
P-85	J-80	MW45	-65.092	.05	3.50	.075	.0266
P-86	J-80	MW43	-210.800	1.11	19.22	.075	.0218
P-87	MW43	MW44	-111.200	.39	10.14	.075	.0236
P-88	MW61	MW62	-117.600	.40	10.73	.075	.0235
P-89	J-84	MW61	-220.400	1.03	20.10	.075	.0217
P-9	J-1	J-7	-2176.670	.01	18.29	.075	.0167
P-90	J-84	MW60	-1144.661	.12	14.37	.075	.0179
P-91	MW60	J-87	-1070.061	.16	13.43	.075	.0180
P-92	J-87	MW64	-100.300	.24	9.15	.075	.0240
P-93	J-87	MW65	-969.761	.09	12.17	.075	.0183
P-94	J-88	MW47	-67.500	.04	6.16	.075	.0256
P-95	J-88	J-91	480.139	.04	6.03	.075	.0202
P-96	J-91	MW40	-556.092	.26	29.91	.075	.0196
P-97	MW59	J-103	310.801	.22	16.72	.075	.0208
P-98	J-92	MW59	241.401	.20	12.98	.075	.0214
P-99	J-92	MW54	-102.800	.25	9.38	.075	.0239
Proposed	Proposed	Proposed	-3582.106	.00	.01	.075	.0315
R-2	R-2	R-2	-2983.194	.00	.01	.075	.0331

JUNCTION NAME	NODE TITLE	DEMAND (USFU)	PRESSURE (USPU)	PRESSURE (PSIA)	PRESSURE (PSIG)	DENSITY #/CF
J-1		.00	-99.73	11.10	-3.60	.075
J-100		.00	-96.70	11.21	-3.49	.075
J-103		.00	-96.51	11.21	-3.48	.075
J-104		.00	-96.51	11.21	-3.48	.075
J-108		.00	-96.53	11.21	-3.48	.075
J-111		.00	-96.54	11.21	-3.49	.075
J-115		.00	-96.56	11.21	-3.49	.075
J-117		.00	-96.61	11.21	-3.49	.075

J-16		.00	-99.68	11.10	-3.60	.075
J-17		.00	-99.68	11.10	-3.60	.075
J-18		.00	-97.94	11.16	-3.54	.075
J-19		.00	-99.68	11.10	-3.60	.075
J-1a		.00	-99.84	11.09	-3.60	.075
J-2		.00	-99.22	11.11	-3.58	.075
J-21		.00	-99.68	11.10	-3.60	.075
J-23		.00	-98.52	11.14	-3.56	.075
J-24		.00	-98.51	11.14	-3.56	.075
J-26		.00	-98.69	11.13	-3.56	.075
J-28		.00	-98.95	11.12	-3.57	.075
J-3		.00	-99.69	11.10	-3.60	.075
J-33		.00	-98.31	11.15	-3.55	.075
J-36		.00	-98.19	11.15	-3.54	.075
J-37		.00	-97.79	11.17	-3.53	.075
J-4		.00	-99.41	11.11	-3.59	.075

JUNCTION NAME	NODE TITLE	DEMAND (USFU)	PRESSURE (USPU)	PRESSURE (PSIA)	PRESSURE (PSIG)	DENSITY #/CF
J-44		.00	-97.33	11.18	-3.51	.075
J-45		.00	-96.92	11.20	-3.50	.075
J-48		.00	-97.03	11.19	-3.50	.075
J-5		.00	-99.62	11.10	-3.60	.075
J-50		.00	-96.78	11.20	-3.49	.075
J-51		.00	-95.67	11.24	-3.45	.075
J-54		.00	-95.75	11.24	-3.46	.075
J-57		.00	-96.15	11.23	-3.47	.075
J-6		.00	-97.80	11.17	-3.53	.075
J-61		.00	-97.73	11.17	-3.53	.075
J-64		.00	-98.38	11.14	-3.55	.075
J-67		.00	-99.15	11.12	-3.58	.075
J-68		.00	-99.77	11.09	-3.60	.075
J-7		.00	-99.71	11.10	-3.60	.075
J-70		.00	-98.54	11.14	-3.56	.075
J-74		.00	-98.45	11.14	-3.55	.075
J-77		.00	-95.74	11.24	-3.46	.075
J-80		.00	-95.70	11.24	-3.45	.075
J-84		.00	-97.15	11.19	-3.51	.075
J-87		.00	-96.87	11.20	-3.50	.075
J-88		.00	-96.55	11.21	-3.49	.075
J-91		.00	-96.59	11.21	-3.49	.075
J-92		.00	-96.09	11.23	-3.47	.075
J-95		.00	-95.99	11.23	-3.47	.075

JUNCTION NAME	NODE TITLE	DEMAND (USFU)	PRESSURE (USPU)	PRESSURE (PSIA)	PRESSURE (PSIG)	DENSITY #/CF
MW01		-66.00	-99.70	11.10	-3.60	.075
MW02		-97.00	-99.66	11.10	-3.60	.075
MW03R		-27.00	-99.40	11.11	-3.59	.075
MW04		-78.00	-99.21	11.11	-3.58	.075
MW05		-40.00	-98.94	11.12	-3.57	.075
MW06		-63.00	-98.67	11.13	-3.56	.075
MW07R1		-16.00	-99.65	11.10	-3.60	.075

MW08		-78.00	-98.50	11.14	-3.56	.075
MW09R		-90.00	-99.63	11.10	-3.60	.075
MW10R		-99.00	-98.61	11.14	-3.56	.075
MW11RR		-66.90	-97.80	11.17	-3.53	.075
MW12		-102.20	-97.85	11.16	-3.53	.075
MW13R		-120.20	-96.12	11.23	-3.47	.075
MW14R		-22.00	-98.50	11.14	-3.56	.075
MW15		-44.00	-98.30	11.15	-3.55	.075
MW16		-46.00	-97.89	11.16	-3.53	.075
MW17R		-101.60	-96.58	11.21	-3.49	.075
MW18		-65.60	-99.46	11.11	-3.59	.075
MW19		-95.80	-99.63	11.10	-3.60	.075
MW20RR		-107.30	-98.61	11.14	-3.56	.075
MW21		-98.30	-98.49	11.14	-3.56	.075
MW22		-106.10	-98.26	11.15	-3.55	.075
MW23		-63.40	-97.12	11.19	-3.51	.075
MW24		-101.60	-95.90	11.23	-3.46	.075
MW25		-113.10	-95.45	11.25	-3.45	.075
MW26		-75.20	-97.02	11.19	-3.50	.075
MW27		-102.20	-96.66	11.21	-3.49	.075
MW28		-111.30	-97.86	11.16	-3.53	.075
MW29		-57.70	-98.68	11.13	-3.56	.075
MW30		-99.60	-97.54	11.17	-3.52	.075
MW31		-109.90	-97.17	11.19	-3.51	.075
MW32		-60.00	-99.73	11.10	-3.60	.075
MW33		-99.60	-98.79	11.13	-3.57	.075
MW34		-109.30	-98.26	11.15	-3.55	.075
MW35		-118.90	-98.14	11.15	-3.54	.075
MW36		-109.30	-97.48	11.18	-3.52	.075
MW37		-118.90	-97.06	11.19	-3.50	.075
MW38		-56.50	-99.67	11.10	-3.60	.075
MW39		-74.60	-96.76	11.20	-3.49	.075
MW40		-66.20	-96.33	11.22	-3.48	.075
MW41		-102.80	-94.89	11.27	-3.43	.075
MW42		-111.20	-94.54	11.28	-3.41	.075
MW43		-99.60	-94.59	11.28	-3.41	.075
MW44		-111.20	-94.20	11.30	-3.40	.075
MW45		-111.20	-95.65	11.24	-3.45	.075
MW46		-118.90	-94.33	11.29	-3.41	.075
MW47		-67.50	-96.51	11.21	-3.48	.075
MW48		-101.60	-96.11	11.23	-3.47	.075
MW49		-108.60	-94.76	11.28	-3.42	.075
MW50		-115.10	-95.45	11.25	-3.45	.075
MW51		-58.80	-98.31	11.15	-3.55	.075
MW52		-99.00	-98.04	11.16	-3.54	.075

JUNCTION NAME	NODE TITLE	DEMAND (USFU)	PRESSURE (USPU)	PRESSURE (PSIA)	PRESSURE (PSIG)	DENSITY #/CF
MW53		-68.10	-97.66	11.17	-3.53	.075
MW54		-102.80	-95.84	11.24	-3.46	.075
MW55		-103.50	-95.99	11.23	-3.47	.075
MW56		-113.80	-95.53	11.25	-3.45	.075
MW57		-109.90	-96.03	11.23	-3.47	.075
MW58		-69.40	-96.48	11.21	-3.48	.075
MW59		-69.40	-96.29	11.22	-3.48	.075

MW60		-74.60	-97.02	11.19	-3.50	.075
MW61		-102.80	-96.12	11.23	-3.47	.075
MW62		-117.60	-95.72	11.24	-3.46	.075
MW63		-75.90	-97.32	11.18	-3.51	.075
MW64		-100.30	-96.62	11.21	-3.49	.075
MW65		-49.60	-96.78	11.20	-3.49	.075
MW66		-92.60	-96.23	11.22	-3.47	.075
MW67		-70.10	-96.51	11.21	-3.48	.075
MW68		-100.30	-96.21	11.22	-3.47	.075
MW69		-73.30	-96.51	11.21	-3.48	.075
MW70		-57.70	-96.52	11.21	-3.48	.075
MW71		-67.50	-96.49	11.21	-3.48	.075
MW72		-40.70	-96.48	11.21	-3.48	.075
MW73		-90.00	-96.29	11.22	-3.48	.075
MW74		-41.80	-96.46	11.21	-3.48	.075
MW75		-89.30	-96.27	11.22	-3.48	.075
MW76		-40.70	-96.67	11.21	-3.49	.075

JUNCTION NAME	NODE TITLE	DEMAND (USFU)	PRESSURE (USPU)	PRESSURE (PSIA)	PRESSURE (PSIG)	DENSITY #/CF
MW77		-36.00	-99.61	11.10	-3.60	.075
MW79R		-99.30	-98.82	11.13	-3.57	.075
MW81		-25.00	-99.64	11.10	-3.60	.075
Proposed F		.00	-100.00	11.09	-3.61	.075
R-2		.00	-100.00	11.09	-3.61	.075

* This designates the use of default density in a low pressure region

THE NET SYSTEM DEMAND (USFU) = -6565.299

SUMMARY OF INFLOWS(+).AND.OUTFLOWS(-) :

NAME	FLOW (USFU)	FPN TITLE
Proposed	-3582.1	Proposed Fla
R-2	-2983.1	R-2

SUMMARY OF MINIMUM.AND.MAXIMUM VELOCITIES (FT/S)

MINIMUM		MAXIMUM	
R-2	.01	P-69	30.43
Proposed	.01	P-96	29.91
P-127	.36	P-66	27.08
P-112	.41	P-59	26.37
P-19	.64	P-61	26.35

SUMMARY OF MINIMUM.AND.MAXIMUM LOSS/1000. (PSI)

MINIMUM		MAXIMUM	
R-2	.00	P-45	.23

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Proposed     .00  P-96           .22
P-112        .00  P-68           .21
P-127        .00  P-59           .18
P-19         .00  P-61           .18

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 SUMMARY OF MINIMUM.AND.MAXIMUM PRESSURES (USPU)
 ----------------------------------------------
       MINIMUM          MAXIMUM
 ---------------------------------------
Proposed-100.00  MW44        -94.20
J-1a       -99.84  MW46        -94.33
J-68       -99.77  MW42        -94.54
MW32       -99.73  MW43        -94.59
J-1        -99.73  MW49        -94.76

 ************************    END OF KYGAS SIMULATION    ************************

 DATE FOR THIS COMPUTER RUN       :  9-18-2014
 START TIME FOR THIS COMPUTER RUN : 15:15:14:66
```

FIGURE 1: PIPE LABELING

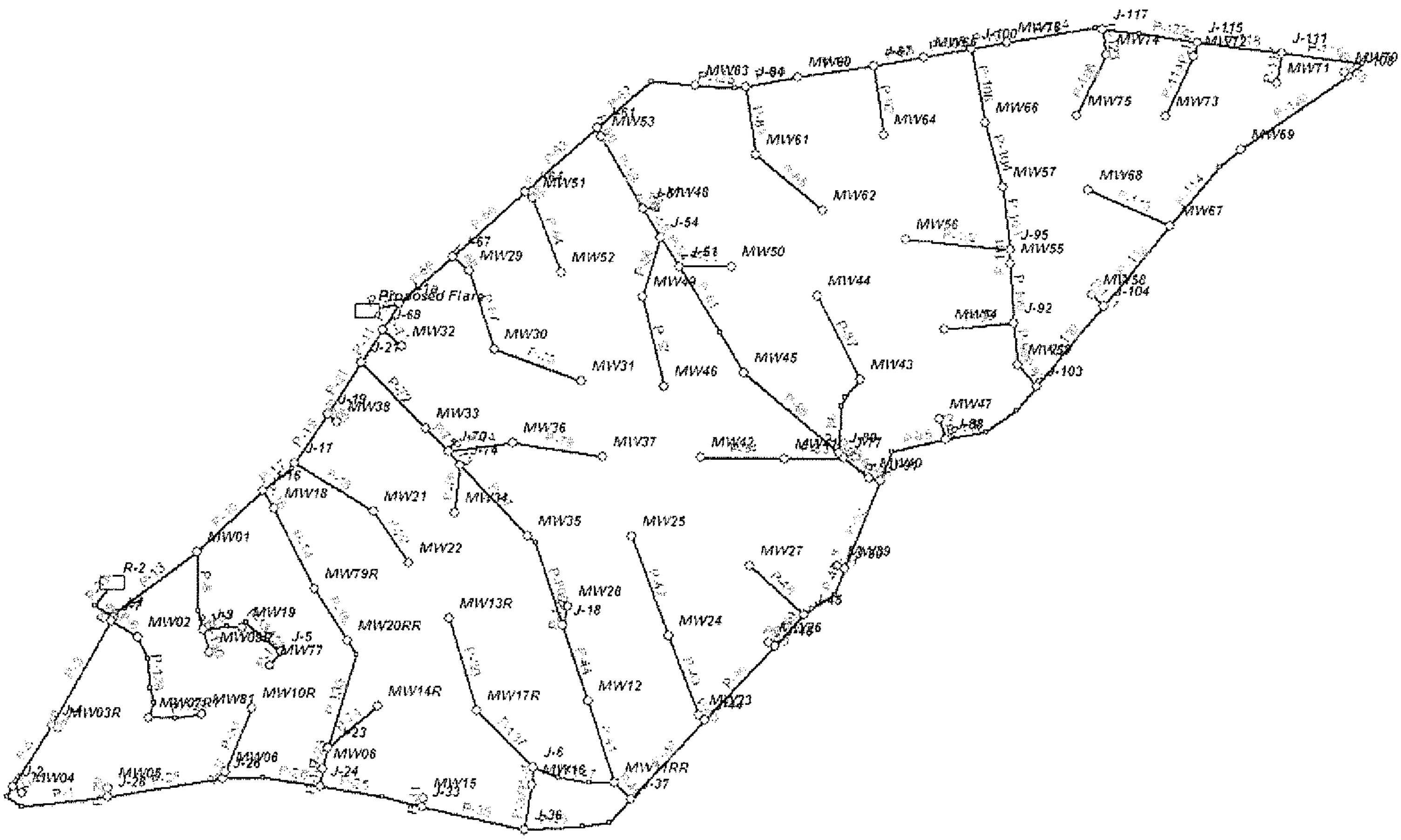
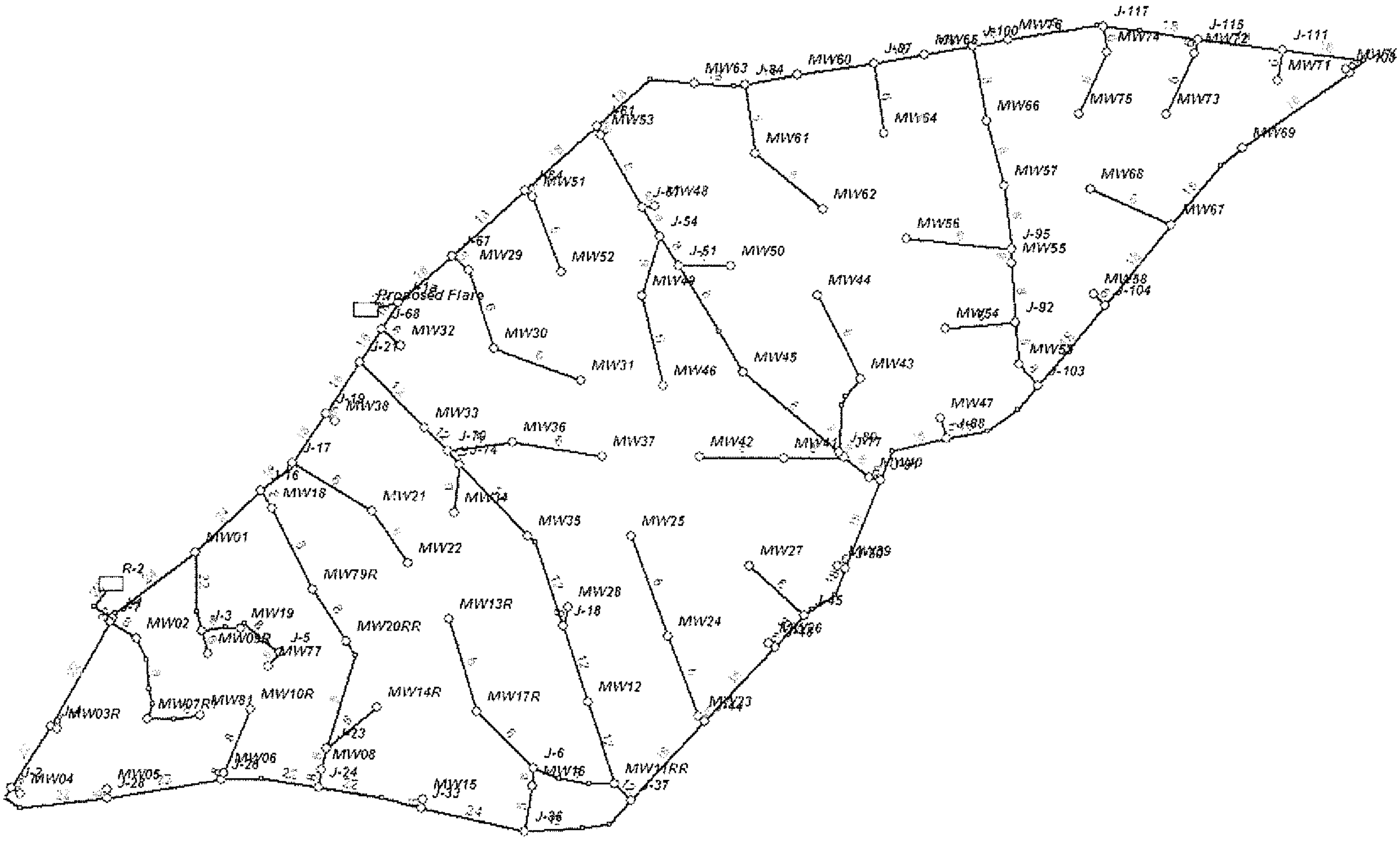
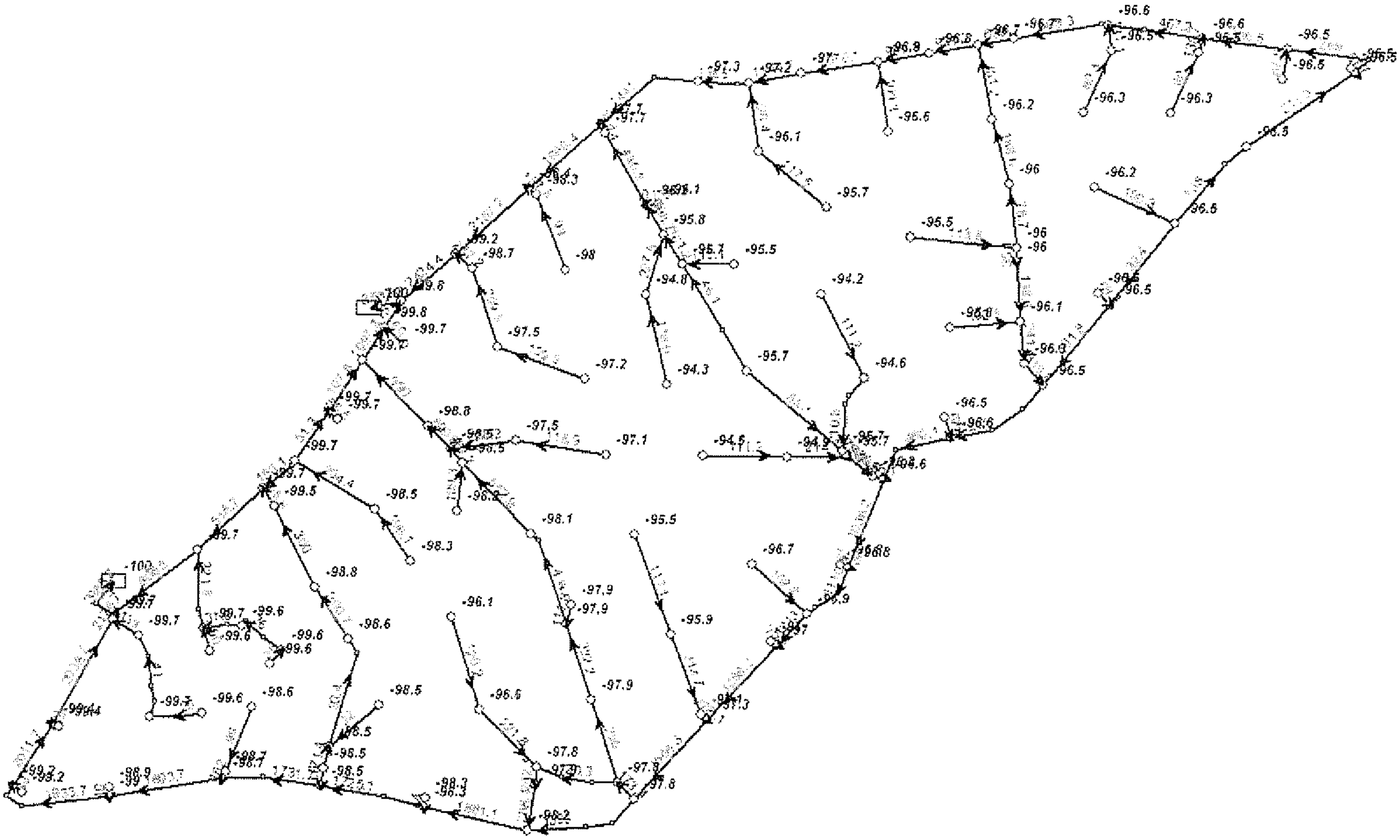


FIGURE 2: PIPE SIZING



WM00106

FIGURE 3: PRESSURE AND FLOW RESULTS



GAS MOVER EQUIPMENT SIZING

INTRODUCTION

Per 40 CFR 60.752(b)(2)(ii)(A)(1), the active gas extraction system must be designed to handle the maximum expected gas flow rate from the entire area of the landfill that warrants control, over the intended use period of the gas control system equipment. 40 CFR 60.752(b)(2)(ii)(A)(3) requires that gas be collected at a sufficient extraction rate.

Since the blower is responsible for providing the vacuum that actually extracts the gas from the well field and moves it through the system, the sizing of the blower is crucial to demonstrating compliance with NSPS requirements. General design criteria and the method for determining the required blower size are discussed in the following section.

GENERAL DESIGN CRITERIA

Flow Volumes:

The blower must provide a uniform source of vacuum over a wide range of flow rates, since gas flow volumes will vary over the life of the gas extraction system. Minimum system flows are those expected when only the initial phases of the system have been installed. Maximum flows will occur after the entire gas system is in place.

Pressure Requirements:

The blower must be capable of supplying sufficient negative pressure to overcome pressure drops and resistance through piping and equipment at the calculated maximum gas flow rate, as well as supplying sufficient positive pressure for delivery of the collected gas to the flare for combustion.

Design Methodologies:

Flow Volumes: The Cottonwood Hills RDF will ultimately require gas mover equipment capable of handling 6,522 cfm landfill gas. This may be accomplished using a series of different size blowers over the life of the facility, since the gas collection system will be installed in phases.

Pressure Losses in Gas System: A discussion of the equation used for calculating pressure losses in the header piping was provided in the discussion on header pipe sizing (KyGAS Analysis). In order to calculate the maximum pressure drop in the system, P_H, the designer must assume a pressure drop across the system due to elbows, tees, and other fittings in the gas system as well as frictional losses from flow in the pipe itself. These losses can range from 15" water column (w.c.) to 45" w.c. depending on the size of the gas collection system. A loss of 38" w.c. is assumed for the future gas collection systems at the Cottonwood Hills RDF.

Applied Well Vacuums: For design purposes, it is assumed that a minimum of 10" water column vacuum, P_W, should be available at the gas wells in order to provide sufficient vacuum for gas extraction. This is consistent with measured vacuums observed by Waste Management during routine gas system monitoring.

Pressure Loss Through Flare: A pressure loss, P_F, on the positive side of the gas mover equipments is created by the discharge piping, the flame arrester, orifice plate and the flare itself. The designer typically assumes a maximum drop of 12" w.c. through these components, based on information supplied by flare manufacturers.

Required Vacuum: Based on these pressure losses for the gas management system, the gas mover equipment must ultimately be capable of providing the following vacuum:

$$P_{total} = P_H + P_W + P_F$$

$$= 38" + 10" + 12"$$
$$= 60" \text{ w.c. total static pressure.}$$

The existing blower at Cottonwood Hills is a 30" Aerovent fan style blower. It is rated at 3000 SCFM at 50 inches w.c. vacuum and has variable frequency drive (VFD) controls. This is sufficient to meet the current needs of the site. Ultimately, gas mover equipment will be selected that can accommodate the total maximum flow of 6,522 cfm while providing static pressures of 60" w.c. The blower size and type utilized may change as needed to accommodate the flows and conditions encountered.

CONTROL DEVICE SIZING

INTRODUCTION

The last requirement in designing a gas collection system is to size and select a control device meeting the requirements of 40 CFR 60.752(b)(2)(iii). The control device must be capable of combusting a wide range of flow volumes.

The Cottonwood Hills RDF operates a utility (open) flare as a control device for the landfill gas. This type of combustion unit meets the control device requirements of the NSPS.

GENERAL DESIGN CRITERIA

40 CFR 60.752(b)(2)(iii)(A) requires that open flares used for control be designed and operated in accordance with 40 CFR 60.18. This includes no visible emissions, and criteria for minimum heating value of the fuel being burned, and exit velocity restrictions.

CONTROL DEVICE SIZING

The current gas system flow measurements at Cottonwood Hills RDF range from 1,200 – 1,500 cfm. The maximum expected gas generation rate is 6,522 cfm. The facility utilizes an open flare as a control device which was authorized for construction via Construction Permit No. 06100058, issued by IEPA on January 10, 2007. A revised Construction Permit No. 06100058 was issued by IEPA on February 27, 2013. The existing flare at the facility can combust gas volumes of up to 3,000 cfm. Based on the current reported flow volumes, the existing control device is sufficient to meet the NSPS control device requirements.

The facility will periodically evaluate the existing gas control capabilities prior to each expansion of the gas collection system to insure that adequate combustion capacity exists for the expected increase in collected gas volumes. All existing and future control devices installed will meet the NSPS requirements for monitoring and performance testing, depending on the type of control device selected.

SECTION III

APPROVED ALTERNATIVE MONITORING/RECORD KEEPING/REPORTING PROCEDURES

APPROVED ALTERNATIVE PROCEDURES

Per 40 CFR 60.752(b)(2)(i)(B), the design plan shall include proposed alternative procedures to the prescriptive monitoring, record keeping and reporting requirements outlined in the NSPS. This section addresses exemptions/alternatives proposed in this submittal. Each of these procedures has already been approved by USEPA at other facilities and the Applicability Determination Index (ADI) Control Number has been provided for reference.

Operational Standard

Section 60.753(a)(1): *"Operate the collection system such that gas is collected from each area, cell, or group of cells in the landfill in which solid waste has been in place for:*
1. 5 years or more if active
2. 2 years or more if closed or at final grade

Permanent vertical wells will only be installed once final grades are reached and the site has been active for 5 years or more or closed or at final grade for 2 years or more. For cells that have been active for 5 years or more and are not yet to final grades, temporary gas extraction wells, horizontal collection trenches and/or the leachate collection system will be used for gas extraction until the wells can be installed (i.e. final grades have been reached). This alternative was approved by USEPA Region 7 for an NSPS landfill in Iowa on February 19, 2004.

If the gas collection system is expanded into areas of the landfill that do not yet meet the above age criteria (for example, for odor control purposes), these wells would not be subject to the monthly monitoring requirements of the NSPS. This is due to the fact that from a waste age standpoint, the area of the landfill where these wells have been placed is not yet subject to control. This was approved by USEPA Region 4 on May 31, 2007 for an NSPS landfill in Tennessee.

Monitoring

§60.756(f): *Any closed landfill that has no monitored exceedances of the operational standard in three consecutive quarterly monitoring periods may skip to annual monitoring.*

Cottonwood Hills RDF will reduce the surface monitoring frequency in certified closed areas of the landfill to an annual basis, once three clean consecutive quarters have been demonstrated in this closed area. The frequency will return to quarterly if a surface emissions exceedance of 500 ppm or more is detected, until such time as the site can demonstrate three consecutive quarters with no exceedances. This alternative monitoring schedule was approved by Region 4 USEPA on July 12, 2004 for an NSPS landfill in Georgia (Applicability Determination Index Control No. 0500087).

No other alternatives to the operational standards, test methods, procedures, compliance measures, monitoring, record keeping, or reporting provisions of §60.753 through §60.758 of the NSPS are proposed at this time.

40 CFR 60.753(d): *"...A surface monitoring design plan shall be developed that includes a topographical map and the rationale for any site specific deviations from the 30 meter intervals. Areas with steep slopes or other dangerous areas may be excluded from surface testing.*

The facility proposes to exclude dangerous areas such as roads, the active area, truck traffic areas, construction areas, areas with snow or ice cover, and slopes steeper than or equal to 4:1 from surface testing. The actual monitoring route followed for each quarter, including areas excluded and reasons for exclusion, shall be included with each surface scan report.

This alternative request has been approved previously by the Region V USEPA, and the states of Illinois, Kentucky and Michigan.

SECTION IV

SURFACE MONITORING PLAN

INTRODUCTION

40 CFR 60.755(c) requires the landfill gas collection system be operated so that the methane concentration is less than 500 ppm above background at the surface of the landfill. In addition, those areas that indicate elevated concentrations of LFG by visual observation (i.e., cracks or seeps in the landfill's cover and distressed vegetation) must also be monitored. This Surface Monitoring Design Plan specifies the monitoring procedures that will be used to meet the NSPS requirement. This plan includes topographical maps with the monitoring routes and specifies the monitoring procedures that will be followed. Any deviations from the surface monitoring requirements as stated in the NSPS are contained in this plan.

Areas Monitored

The NSPS requires monitoring along the entire perimeter of the collection area and along a serpentine pattern spaced 30 meters apart for each collection area on a quarterly basis.

The attached map shows the surface monitoring route proposed for the facility. Areas which may be excluded during a particular quarter, depending on field conditions at the time of the surface scan, include the following:

- Active areas of the site. Active areas are those areas which only have daily cover, and are being filled with waste. Active areas of the landfill have a larger volume of equipment traffic which poses an unacceptable health and safety risk to an individual in the area.
- Areas of the landfill with slopes equal to or greater than 4:1 (horizontal to vertical). These slopes present a safety hazard to the monitoring technician traversing them.
- Areas of the site with snow or ice cover. Snow has the potential to cover uneven surfaces in the landfill cover (such as ruts) which could cause the technician to twist or break a leg. Icy slopes are difficult and dangerous to traverse.
- Areas of the site that are undergoing construction or final cover activities. These areas also have a large volume of equipment traffic, which poses a health and safety risk to the technician performing the scan.

Any areas which are excluded will be documented on the route map generated for that quarter's scan.

Monitoring Frequency

Surface monitoring will normally occur on a quarterly basis in the active areas subject to NSPS controls. Per ADI Control No. 0500087, monitoring in areas which have been certified closed may occur on an annual basis once three clean quarters have been demonstrated.

Monitoring will be rescheduled if it cannot be conducted because temperature conditions are outside the operating range of the instrument and/or other conditions (snow cover, rain storms, etc.) prevent monitoring. The monitoring event will be rescheduled as soon as practical after the original scheduled date.

Surface Monitoring Instrument

The monitoring will be conducted with an organic vapor analyzer, flame ionization detector, or other portable monitor meeting the specifications in 40 CFR 60.755(d):

> "The portable analyzer shall meet the instrument specifications provided in section 3 of Method 21 of Appendix A of 40 CFR Part 60 (Method 21), except that "methane" shall replace all references to VOC."

To meet the performance evaluation requirements of Method 21, the instrument evaluation procedures of Method 21 shall be used. The performance evaluation results will be documented in an instrument logbook or on a form similar to the one shown in Table A-1.

Surface Monitoring Survey

Immediately before commencing a surface monitoring survey, the instrument shall be calibrated per section 4.2 of Method 21. The calibration gas shall be methane, diluted to a nominal concentration of 500 parts per million in air. Calibrations will be documented in an instrument logbook or on a form similar to the one shown in Table A-2.

The background concentration at the facility will be determined immediately prior to conducting the survey. The background concentration shall be determined by moving the probe inlet upwind outside the boundary of the landfill at least 30 meters from the perimeter wells. The background concentration, measurement location, and basic meteorological conditions will be recorded on Table 2. Other factors that can affect "background" should be noted and accounted for (such as a nearby landfill, highway, refinery, chemical plant, etc.).

Surface emission monitoring shall be performed in accordance with section 4.3.1 of Method 21, except that the probe inlet shall be placed within 5 to 10 centimeters (2 to 4 inches) of the ground surface and the probe will be moved continuously along the ground surface. Monitoring will not be performed during extreme meteorological conditions.

Surface monitoring will be conducted around the perimeter of the collection area and the route shown on the topographic map. Areas where visual observations indicate potential elevated concentrations of landfill gas, such as distressed vegetation and cracks or seeps in the cover, will be monitored.

For purposes of monitoring a crack, erosion or similar feature, "ground surface" in such cases is defined by the surface projected between the edges of said feature. Monitoring will be performed with the probe inlet at the appropriate height above this projected surface. In no case will monitoring be performed by inserting the probe inlet into the feature.

Any reading of 500 parts per million or more above background at any location shall be recorded as a monitored exceedance and the following actions shall be taken:

i. The location of each monitored exceedance shall be marked and the location recorded. Table A-3 is a typical form for documenting monitoring exceedances. Other forms for tracking exceedances may be utilized.

ii. Cover maintenance or adjustments to the vacuum of the adjacent wells to increase the gas collection in the vicinity of each exceedance shall be made and the location shall be re-monitored within 10 calendar days of detecting the exceedance.

iii. If the re-monitoring of the location shows a second exceedance, additional corrective action shall be taken and the location shall be monitored again within 10 days of the second exceedance. If the re-monitoring shows a third exceedance for the same location, the action specified in paragraph (v) below shall be taken, and no further monitoring of that location is required until the action specified in paragraph (v) has been taken.

iv. Any location that initially showed an exceedance but has a methane concentration less than 500 ppm methane above background at the 10-day re-monitoring specified in paragraph (c)(4) (ii) or (iii) of this section shall be re-monitored 1 month from the initial exceedance. If the 1-month remonitoring shows a concentration less than 500 parts per million above background, no further monitoring of that location is required until the next quarterly monitoring period. If the 1-month remonitoring shows an exceedance, the actions specified in paragraph (iii) or (v) shall be taken.

v. For any location where monitored methane concentration equals or exceeds 500 parts per million above background three consecutive times within a quarterly period, a new well or other collection device shall be installed within 120 calendar days of the initial exceedance. An alternative remedy to the exceedance, such as upgrading the blower, header pipes or control device, and a corresponding timeline for installation may be submitted to the Administrator for approval.

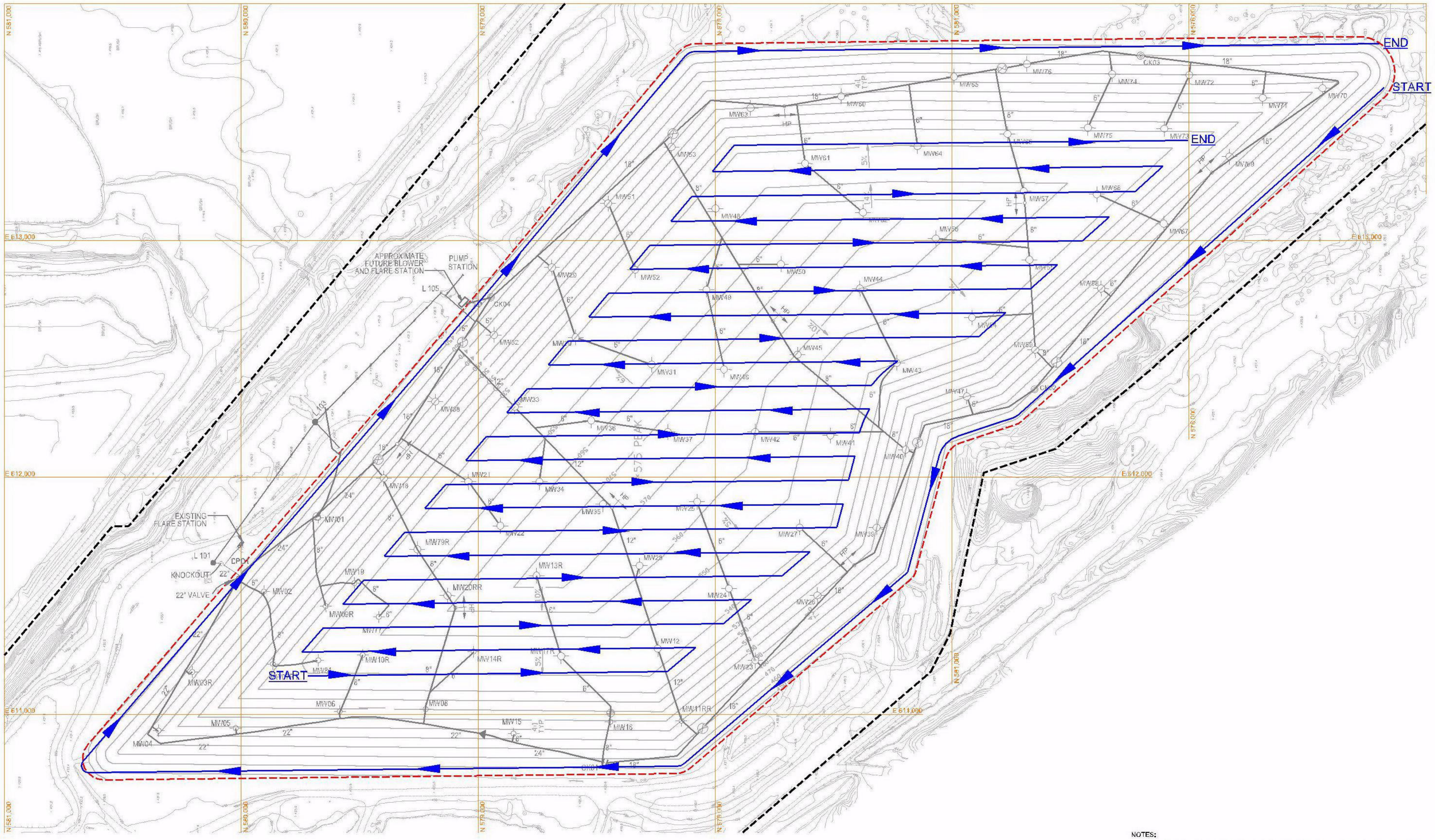
Reduced Monitoring Frequency for Closed Landfills

Any closed landfill that has no monitored exceedances of the 500 ppm limit above background in three consecutive quarterly monitoring periods may skip to annual monitoring. Any methane reading of 500 ppm or more above background detected during the annual monitoring returns the frequency to quarterly monitoring. Per ADI Control No. 0500087, monitoring in areas which have been certified closed may occur on an annual basis once three clean quarters have been demonstrated.

Cover Integrity Monitoring

40 CFR 60.755(b)(5) requires a program to monitor for cover integrity and implement cover repairs

as necessary on a monthly basis. During the inspection, facility personnel will conduct a site walk of the landfill to inspect the cover. The inspector will look for signs of compromised cover integrity such as stressed vegetation, cracks, and erosion. The inspection will be documented on a form similar to the one shown in Table A-4 or on the Facility Daily Operating Record (DOR). Areas of compromised integrity will be noted. The appropriate facility personnel will be notified of the compromised areas so that corrective actions can be taken.



NOTES:

1. TOPOGRAPHIC BASE MAP PROVIDED BY SURDEX CORPORATION, DATED FEBRUARY 3, 2014.
2. CURRENT TOPOGRAPHY MAY DIFFER FROM THAT SHOWN DUE TO ON-GOING LANDFILLING OPERATIONS SINCE THE DATE OF THE AERIAL SURVEY.
3. FOR CLARITY NOT ALL SITE FEATURES ARE SHOWN.
4. THE PROPOSED SURFACE MONITORING PLAN/ROUTE REPRESENTS A TYPICAL PLAN TO BE FOLLOWED ONCE THE SITE IS PERMANENTLY CLOSED. DEPENDING ON THE ACTUAL FIELD CONDITIONS, THE ACTUAL SURFACE MONITORING MAY FOLLOW A DIFFERENT ROUTE. HOWEVER, THE ROUTE SHALL MEET THE NSPS REQUIREMENTS. SOME AREAS MAY BE EXCLUDED FROM SURFACE EMISSIONS MONITORING AS APPROVED IN NSPS DESIGN PLAN.
5. FINAL GRADES PROVIDED BY WASTE MANAGEMENT, DRAWING 1, TITLED AS-BUILT GAS SYSTEM, DATED APRIL 2007.

NO	REVISIONS	DRN	CHK	DATE

DRN
DES
CHK
APP

PREPARED FOR

WASTE MANAGEMENT

PREPARED BY

ENVIRONMENTAL INFORMATION LOGISTICS, LLC

COTTONWOOD HILLS RECYCLING AND DISPOSAL FACILITY - NSPS LANDFILL GAS MANAGEMENT SYSTEM PLANS

SURFACE SCAN MAP

DATE	SEPTEMBER 2014
PROJECT NO	131203
FILENAME	001 CW SC PLAN 091214
SHEET NO	1 OF 1
FIGURE NO	1

WM00119

Table A - 1
Monitoring Instrument Performance Evaluation
Surface Monitoring Design Plan

40 CFR 60.755(d)(3) requires performance evaluation of response factor, response time and calibration precision according to the section 4.4 of 40 CFR 60 Appendix A, Method 21. The requirements are presented below along with locations to record the evaluations.

Response Factor:
Response factor is the ratio of the known concentration of a VOC compound to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation. Since the monitoring instrument is being used to detect methane and the calibration reference compound is methane, the response factor by definition is one. No further evaluation is required.

Response Time:
Response time is the time interval from a step change in VOC concentration at the input of the sampling system to the time at which 9 percent of the corresponding final value is reached as displayed on the instrument readout meter.

Performance Requirement: Section 3.1.2(b) of Method 21 requires the instrument response time to be equal to or less than 30 seconds.

Evaluation Frequency: Prior to placing instrument into service (for the first time or after it was out of service for maintenance or repair). If modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required prior to further use.

Evaluation Procedure: (Section 4.4.3 of Method 21) Calibrate instrument with the methane calibration gas. Introduce zero gas into the instrument sample probe. When the meter reading has stabilized, switch quickly to the specified calibration gas. Measure the time from switching to when 90 percent of the final stable reading is attained. Perform this test sequence three time and record the results. Calculate the average response time. Use the form below or a similar format to document this procedure.

Date: ____________________
Operator Name: ____________________
Facility: ____________________
Instrument ID: ____________________
Calibration Gas Conc.: ____________________
90% of Calib. Gas Conc.: ____________________

Trial No.	Time to reach 90% gas value
1	____________ seconds
2	____________ seconds
3	____________ seconds
Average	____________ seconds

Table A - 1
Monitoring Instrument Performance Evaluation
Surface Monitoring Design Plan
(cont.)

Calibration Precision:

Calibration precision is the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration.

Performance Requirement: The calibration precision must be equal to or less than 10 percent of the calibration gas value.

Evaluation Frequency: Must be completed prior to placing instrument into service, and at subsequent 3-month intervals or at the next use whichever is later.

Evaluation Procedure: (Section 4.4.2 of Method 21) Calibrate instrument with the methane calibration gas. Make a total of three measurements by alternately using zero gas and the specified calibration gas. Record the meter readings. Calculate the average algebraic difference between the meter readings and the known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

Date: ______________________
Operator Name: ______________________
Facility: ______________________
Instrument ID: ______________________
Calibration Gas Conc.: ______________________

Trial No.	Meter Reading After Zero Gas	Difference Between Calibration Gas and Meter Reading
1	____________ppm	____________ppm
2	____________ppm	____________ppm
3	____________ppm	____________ppm

Average Difference: ____________ppm

Calibration Precision = Average Difference/Calibration Gas Conc. X 100%
= ____________ / ____________ X 100%
= ________%

WM00121

Table A - 2
Instrument Calibration and Monitoring Procedures
Surface Monitoring Design Plan

The calibration procedures in section 4.2 of 40 CFR 60 Appendix A, Method 21 must be conducted immediately before commencing a surface monitoring survey. [40 CFR 60.755(d)(4)] Calibration, background readings and monitoring details can be recorded using this form.

Calibration Procedure:
The calibration gas should be methane in air at a nominal concentration of 500 ppm. [See section 3.2 of Method 21 for further calibration gas requirements.]

Assemble and start up the analyzer according to the manufacturer's instructions. After the appropriate warm-up period and zero internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value. Record the calibration information in the table below.

Background Concentration:
Determine the background concentration by moving the probe inlet upwind outside the boundary of the landfill at a distance of at least 30 meters from the perimeter wells. Record the background concentration and location in the table below.

General Information:
Date: ______________________
Operator Name: ______________________
Facility: ______________________
Instrument ID: ______________________
Wind Direction: N NE E SE S SW W NW (circle one)
Approximate Wind Speed______________________mph
General Weather: ______ °F,
clear, partly cloudy, overcast, ____________ (circle one or write in)
no precip., drizzle, rain, snow, ____________ (circle one or write in)

Calibration Information:
Calibration Gas Conc.: __________ppm
Conduct internal zero calibration? Yes No (circle one)
Instrument reading after calibration: __________ppm (should be same as above)
Time of Calibration: ___:___ am pm (fill in and pick one)

Background Concentration Information:
Background concentration upwind of site: ____________ppm
Background concentrations downwind of site: ____________ppm

Location of background readings:____

Table A - 3
Individual Monitoring Exceedance
Surface Monitoring Design Plan

Use this form to record an individual monitoring exceedance and follow-up monitoring activities. This form is only used when a reading of 500 ppm above background is encountered during the surface monitoring. Use a separate form for each initial exceedance.

Initial Monitoring Exceedance:
Date: ___________ Time:_________am pm Monitoring Technician Initials:_________
Instrument reading - Background reading: ________ppm - ________ppm = _______ppm

Location of monitored exceedance (include description of field marker used):

Describe cover maintenance or adjustments to the vacuum of adjacent wells to increase gas collection in vicinity of measured exceedance before remonitoring in 10 days:

Remonitor location within 10 calendar days of initial exceedance:
Date: ___________ Time:__________am pm Monitoring Technician Initials:_________
Instrument reading - Background reading: _______ppm - _______ppm = _______ppm

If 10 day remonitoring shows an exceedance, describe additional corrective action taken before remonitoring again within 10 days:

If the 10 day remonitoring is <500 ppm, remonitor 1 month from initial exceedance:
Date: ___________ Time:_________am pm Monitoring Technician Initials:_________
Instrument reading - Background reading: _______ppm - _______ppm = _______ppm

If the 1 month remonitoring is <500 ppm, resume normal quarterly monitoring.
If the 1 month remonitoring shows an exceedance, describe additional corrective action taken before remonitoring again within 10 days:

Remonitor location within 10 calendar days of 2nd exceedance:
Date: ___________ Time:_________am pm Monitoring Technician Initials:_________
Instrument reading - Background reading: _______ppm - _______ppm = _______ppm

If the 10 day remonitoring is <500 ppm, remonitor 1 month from initial exceedance:
Date: ___________ Time:_______am pm Monitoring Technician Initials:_________
Instrument reading - Background reading: _______ppm - _______ppm = _______ppm

If the 1 month remonitoring is <500 ppm, resume normal quarterly monitoring.
If the 1 month remonitoring shows an exceedance, describe additional corrective action taken before remonitoring again within 10 days:

(use additional forms if necessary)*

*If remonitoring shows 3 <u>consecutive</u> exceedances within a quarterly period a new well or other collection device must be installed within 120 days of <u>initial</u> exceedance or alternative remedies/timelines may be submitted to the Administrator for approval. Further monitoring is not necessary until the remedy is completed.

Table A – 4
Monthly Cover Integrity Inspection
Surface Monitoring Design Plan

Month	**Inspection Date**	**Inspector Initials**	**Cover Integrity Problems Found During Inspection**
January	____/____/____		
February	____/____/____		
March	____/____/____		
April	____/____/____		
May	____/____/____		
June	____/____/____		
July	____/____/____		
August	____/____/____		
September	____/____/____		
October	____/____/____		
November	____/____/____		
December	____/____/____		

APPENDIX A
40 CFR 60 Appendix A, Method 21

1.0 Scope and Application

1.1 Analytes.

Analyte	CAS No.
Volatile Organic Compounds (VOC)..........	No CAS number assigned.

1.2 Scope. This method is applicable for the determination of VOC leaks from process equipment. These sources include, but are not limited to, valves, flanges and other connections, pumps and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals, and access door seals.

1.3 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method

2.1 A portable instrument is used to detect VOC leaks from individual sources. The instrument detector type is not specified, but it must meet the specifications and performance criteria contained in Section 6.0. A leak definition concentration based on a reference compound is specified in each applicable regulation. This method is intended to locate and classify leaks only, and is not to be used as a direct measure of mass emission rate from individual sources.

3.0 Definitions

3.1 *Calibration gas* means the VOC compound used to adjust the instrument meter reading to a known value. The calibration gas is usually the reference compound at a known concentration approximately equal to the leak definition concentration.

3.2 *Calibration precision* means the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration.

3.3 *Leak definition concentration* means the local VOC concentration at the surface of a leak source that indicates that a VOC emission (leak) is present. The leak definition is an instrument meter reading based on a reference compound.

3.4 *No detectable emission* means a local VOC concentration at the surface of a leak source, adjusted for local VOC ambient concentration, that is less than 2.5 percent of the specified leak definition concentration. that indicates that a VOC emission (leak) is not present.

3.5 *Reference compound* means the VOC species selected as the instrument calibration basis for specification of the leak definition concentration. (For example, if a leak definition concentration is 10,000 ppm as methane, then any source emission that results in a local concentration that yields a meter reading of 10,000 on an instrument meter calibrated with methane would be classified as a leak. In this example, the leak definition concentration is 10,000 ppm and the reference compound is methane.)

3.6 *Response factor* means the ratio of the known concentration of a VOC compound to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation.

3.7 *Response time* means the time interval from a step change in VOC concentration at the input of the sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the instrument readout meter.

4.0 Interferences [Reserved]

5.0 Safety

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

5.2 Hazardous Pollutants. Several of the compounds, leaks of which may be determined by this method, may be irritating or corrosive to tissues (*e.g.*, heptane) or may be toxic (*e.g.*, benzene, methyl alcohol). Nearly all are fire hazards. Compounds in emissions should be determined through familiarity with the source. Appropriate precautions can be found in reference documents, such as reference No. 4 in Section 16.0.

6.0 Equipment and Supplies

A VOC monitoring instrument meeting the following specifications is required:

6.1 The VOC instrument detector shall respond to the compounds being processed. Detector types that may meet this requirement include, but are not limited to, catalytic oxidation, flame ionization, infrared absorption, and photoionization.

6.2 The instrument shall be capable of measuring the leak definition concentration specified in the regulation.

6.3 The scale of the instrument meter shall be readable to ±2.5 percent of the specified leak definition concentration.

6.4 The instrument shall be equipped with an electrically driven pump to ensure that a sample is provided to the detector at a constant flow rate. The nominal sample flow rate, as measured at the sample probe tip, shall be 0.10 to 3.0 l/min (0.004 to 0.1 ft^3/min) when the probe is fitted with a glass wool plug or filter that may be used to prevent plugging of the instrument.

6.5 The instrument shall be equipped with a probe or probe extension or sampling not to exceed 6.4 mm (1/4 in) in outside diameter, with a single end opening for admission of sample.

6.6 The instrument shall be intrinsically safe for operation in explosive atmospheres as defined by the National Electrical Code by the National Fire Prevention Association or other applicable regulatory code for operation in any explosive atmospheres that may be encountered in its use. The instrument shall, at a minimum, be intrinsically safe for Class 1, Division 1 conditions, and/or Class 2, Division 1 conditions, as appropriate, as defined by the example code. The instrument shall not be operated with any safety device, such as an exhaust flame arrestor, removed.

7.0 Reagents and Standards

7.1 Two gas mixtures are required for instrument calibration and performance evaluation:

7.1.1 Zero Gas. Air, less than 10 parts per million by volume (ppmv) VOC.

7.1.2 Calibration Gas. For each organic species that is to be measured during individual source surveys, obtain or prepare a known standard in air at a concentration approximately equal to the applicable leak definition specified in the regulation.

7.2 Cylinder Gases. If cylinder calibration gas mixtures are used, they must be analyzed and certified by the manufacturer to be within 2 percent accuracy, and a shelf life must be specified. Cylinder standards must be either reanalyzed or replaced at the end of the specified shelf life.

7.3 Prepared Gases. Calibration gases may be prepared by the user according to any accepted gaseous preparation procedure that will yield a mixture accurate to within 2 percent. Prepared standards must be replaced each day of use unless it is demonstrated that degradation does not occur during storage.

7.4 Mixtures with non-Reference Compound Gases. Calibrations may be performed using a compound other than the reference compound. In this case, a conversion factor must be determined for the alternative compound such that the resulting meter readings during source surveys can be converted to reference compound results.

8.0 Sample Collection, Preservation, Storage, and Transport

8.1 Instrument Performance Evaluation. Assemble and start up the instrument according to the manufacturer's instructions for recommended warmup period and preliminary adjustments.

8.1.1 Response Factor. A response factor must be determined for each compound that is to be measured, either by testing or from reference sources. The response factor tests are required before placing the analyzer into service, but do not have to be repeated at subsequent intervals.

8.1.1.1 Calibrate the instrument with the reference compound as specified in the applicable regulation. Introduce the calibration gas mixture to the analyzer and record the observed meter reading. Introduce zero gas until a stable reading is obtained. Make a total of three measurements by alternating between the calibration gas and zero gas. Calculate the response factor for each repetition and the average response factor.

8.1.1.2 The instrument response factors for each of the individual VOC to be measured shall be less than 10 unless otherwise specified in the applicable regulation. When no instrument is available that meets this specification when calibrated with the reference VOC specified in the applicable regulation, the available instrument may be calibrated with one of the VOC to be measured, or any other VOC, so long as the instrument then has a response factor of less than 10 for each of the individual VOC to be measured.

8.1.1.3 Alternatively, if response factors have been published for the compounds of interest for the instrument or detector type, the response factor determination is not required, and existing results may be referenced. Examples of published response factors for flame ionization and catalytic oxidation detectors are included in References 1–3 of Section 17.0.

8.1.2 Calibration Precision. The calibration precision test must be completed prior to placing the analyzer into service and at subsequent 3-month intervals or at the next use, whichever is later.

8.1.2.1 Make a total of three measurements by alternately using zero gas and the specified calibration gas. Record the meter readings. Calculate the average algebraic difference between the meter readings and the known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

8.1.2.2 The calibration precision shall be equal to or less than 10 percent of the calibration gas value.

8.1.3 Response Time. The response time test is required before placing the instrument into service. If a modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required before further use.

8.1.3.1 Introduce zero gas into the instrument sample probe. When the meter reading has stabilized, switch quickly to the specified calibration gas. After switching, measure the time required to attain 90 percent of the final stable reading. Perform this test sequence three times and record the results. Calculate the average response time.

8.1.3.2 The instrument response time shall be equal to or less than 30 seconds. The instrument pump, dilution probe (if any), sample probe, and probe filter that will be used during testing shall all be in place during the response time determination.

8.2 Instrument Calibration. Calibrate the VOC monitoring instrument according to Section 10.0.

8.3 Individual Source Surveys.

8.3.1 Type I—Leak Definition Based on Concentration. Place the probe inlet at the surface of the component interface where leakage could occur. Move the probe along the interface periphery while observing the instrument readout. If an increased meter reading is observed, slowly sample the interface where leakage is indicated until the maximum meter reading is obtained. Leave the probe inlet at this maximum reading location for approximately two times the instrument response time. If the maximum observed meter reading is greater than the leak definition in the applicable regulation, record and report the results as specified in the regulation reporting requirements. Examples of the application of this general technique to specific equipment types are:

8.3.1.1 Valves. The most common source of leaks from valves is the seal between the stem and housing. Place the probe at the interface where the stem exits the packing gland and sample the stem circumference. Also, place the probe at the interface of the packing gland take-up flange seat and sample the periphery. In addition, survey valve housings of multipart assembly at the surface of all interfaces where a leak could occur.

8.3.1.2 Flanges and Other Connections. For welded flanges, place the probe at the outer edge of the flange-gasket interface and sample the circumference of the flange. Sample other types of nonpermanent joints (such as threaded connections) with a similar traverse.

8.3.1.3 Pumps and Compressors. Conduct a circumferential traverse at the outer surface of the pump or compressor shaft and seal interface. If the source is a rotating shaft, position the probe inlet within 1 cm of the shaft-seal interface for the survey. If the housing configuration prevents a complete traverse of the shaft periphery, sample all accessible portions. Sample all other joints on the pump or compressor housing where leakage could occur.

8.3.1.4 Pressure Relief Devices. The configuration of most pressure relief devices prevents sampling at the sealing seat interface. For those devices equipped with an enclosed extension, or horn, place the probe inlet at approximately the center of the exhaust area to the atmosphere.

8.3.1.5 Process Drains. For open drains, place the probe inlet at approximately the center of the area open to the atmosphere. For covered drains, place the probe at the surface of the cover interface and conduct a peripheral traverse.

8.3.1.6 Open-ended Lines or Valves. Place the probe inlet at approximately the center of the opening to the atmosphere.

8.3.1.7 Seal System Degassing Vents and Accumulator Vents. Place the probe inlet at approximately the center of the opening to the atmosphere.

8.3.1.8 Access door seals. Place the probe inlet at the surface of the door seal interface and conduct a peripheral traverse.

8.3.2 Type II—"No Detectable Emission". Determine the local ambient VOC concentration around the source by moving the probe randomly upwind and downwind at a distance of one to two meters from the source. If an interference exists with this determination due to a nearby emission or leak, the local ambient concentration may be determined at distances closer to the source, but in no case shall the distance be less than 25 centimeters. Then move the probe inlet to the surface of the source and determine the concentration as outlined in Section 8.3.1. The difference between these concentrations determines whether there are no detectable emissions. Record and report the results as specified by the regulation. For those cases where the regulation requires a specific device installation, or that specified vents be ducted or piped to a control device, the existence of these conditions shall be visually confirmed. When the regulation also requires that no detectable emissions exist, visual observations and sampling surveys are required. Examples of this technique are:

8.3.2.1 Pump or Compressor Seals. If applicable, determine the type of shaft seal. Perform a survey of the local area ambient VOC concentration and determine if detectable emissions exist as described in Section 8.3.2.

8.3.2.2 Seal System Degassing Vents, Accumulator Vessel Vents, Pressure Relief Devices. If applicable, observe whether or not the applicable ducting or piping exists. Also, determine if any sources exist in the ducting or piping where emissions could occur upstream of the control device. If the required ducting or piping exists and there are no sources where the emissions could be vented to the atmosphere upstream of the control device, then it is presumed that no detectable emissions are present. If there are sources in the ducting or piping where emissions could be vented or sources where leaks could occur, the sampling surveys described in Section 8.3.2 shall be used to determine if detectable emissions exist.

8.3.3 Alternative Screening Procedure.

8.3.3.1 A screening procedure based on the formation of bubbles in a soap solution that is sprayed on a potential leak source may be used for those sources that do not have continuously moving parts, that do not have surface temperatures greater than the boiling point or less than the freezing point of the soap solution, that do not have open areas to the atmosphere that the soap solution cannot bridge, or that do not exhibit evidence of liquid leakage. Sources that have these conditions present must be surveyed using the instrument technique of Section 8.3.1 or 8.3.2.

8.3.3.2 Spray a soap solution over all potential leak sources. The soap solution may be a commercially available leak detection solution or may be prepared using concentrated detergent and water. A pressure sprayer or squeeze bottle may be used to dispense the solution. Observe the potential leak sites to determine if any bubbles are formed. If no bubbles are observed, the source is presumed to have no detectable emissions or leaks as applicable. If any bubbles are observed, the instrument techniques of Section 8.3.1 or 8.3.2 shall be used to determine if a leak exists, or if the source has detectable emissions, as applicable.

9.0 Quality Control

Section	Quality control measure	Effect
8.1.2	Instrument calibration precision check.	Ensure precision and accuracy, respectively, of instrument response to standard.
10.0	Instrument calibration.	

10.0 Calibration and Standardization

10.1 Calibrate the VOC monitoring instrument as follows. After the appropriate warmup period and zero internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value.

Note: If the meter readout cannot be adjusted to the proper value, a malfunction of the analyzer is indicated and corrective actions are necessary before use.

11.0 Analytical Procedures [Reserved]

12.0 Data Analyses and Calculations [Reserved]

13.0 Method Performance [Reserved]

14.0 Pollution Prevention [Reserved]

15.0 Waste Management [Reserved]

16.0 References

1. Dubose, D.A., and G.E. Harris. Response Factors of VOC Analyzers at a Meter Reading of 10,000 ppmv for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2–81051. September 1981.

2. Brown, G.E., *et al.* Response Factors of VOC Analyzers Calibrated with Methane for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2–81–022. May 1981.

3. DuBose, D.A. *et al.* Response of Portable VOC Analyzers to Chemical Mixtures. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2–81–110. September 1981.

4. Handbook of Hazardous Materials: Fire, Safety, Health. Alliance of American Insurers. Schaumberg, IL. 1983.

SECTION V

PROFESSIONAL ENGINEERING CERTIFICATION OF DESIGN PLAN

CERTIFICATION STATEMENT

I certify that the Revised Landfill Gas Collection and Control System Design Plan for the Cottonwood Hills Recycling and Disposal Facility was prepared in general accordance with the requirements of 40 CFR 60 Subpart WWW.

Signed,

LAURA L. NIEMANN
062-049010
LICENSED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

Laura L. Niemann, P.E.

9/22/2014

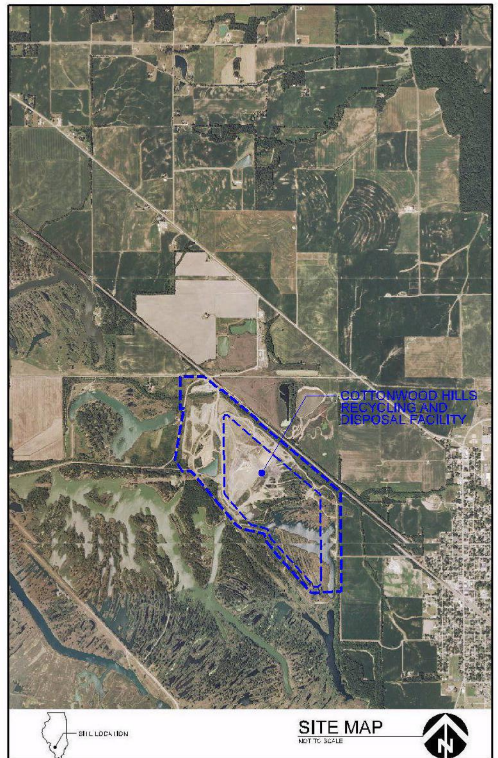
APPENDIX A

EXISTING AND PROPOSED GAS COLLECTION SYSTEM DESIGN

REVISED NSPS GAS SYSTEM DESIGN PLANS FOR

COTTONWOOD HILLS RECYCLING AND DISPOSAL FACILITY
MARISSA, ILLINOIS

SEPTEMBER 2014



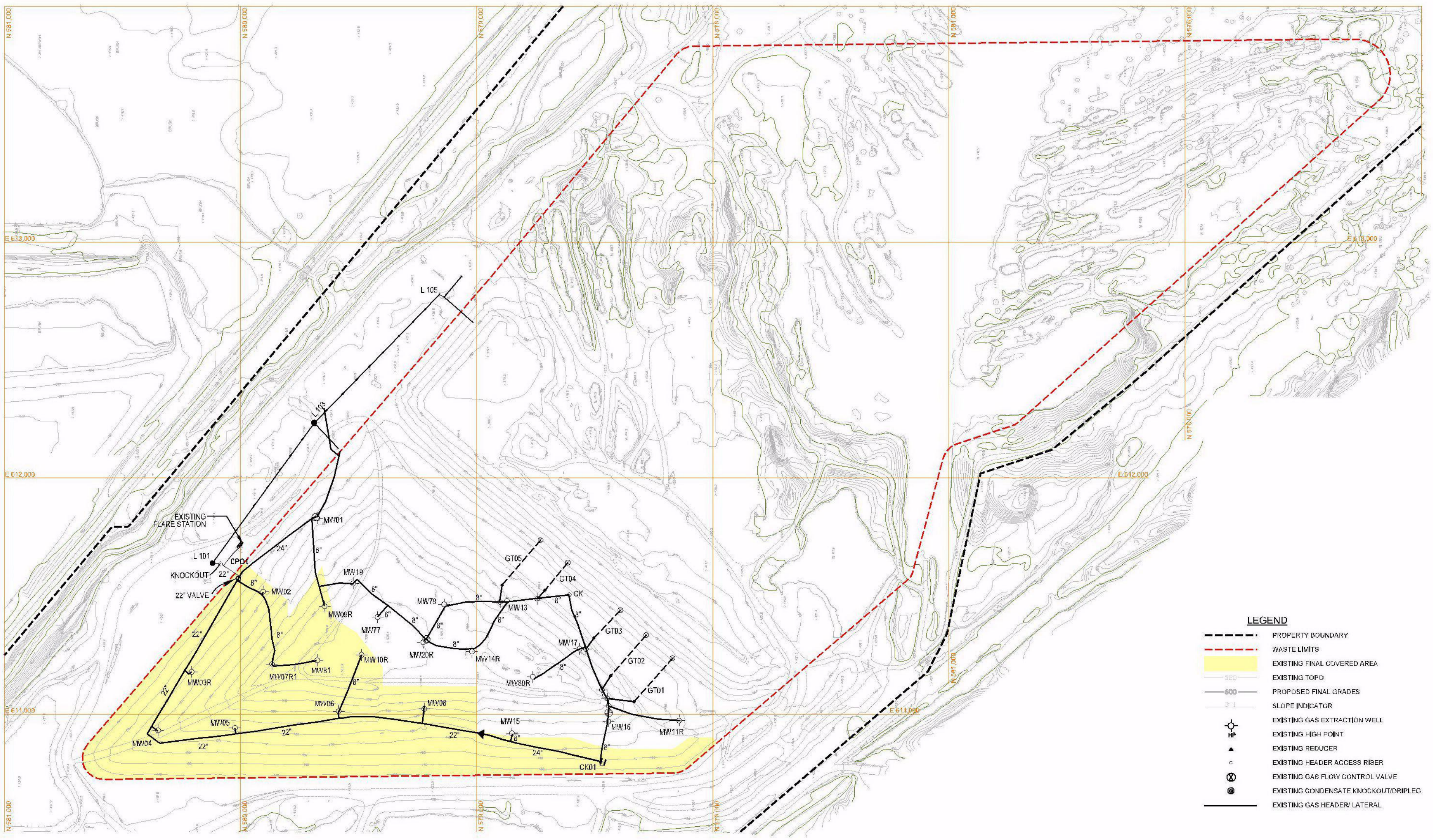
PREPARED FOR

WASTE MANAGEMENT
COTTONWOOD HILLS RECYCLING AND DISPOSAL FACILITY
10400 HILLSTOWN ROAD
MARISSA, ILLINOIS 62257
(618) 295-2800

PREPARED BY

EIL
ENVIRONMENTAL INFORMATION LOGISTICS, LLC

WM00136



NOTES:

1. TOPOGRAPHIC BASE MAP PROVIDED BY SURDEX CORPORATION, DATED FEBRUARY 3, 2014.
2. CURRENT TOPOGRAPHY MAY DIFFER FROM THAT SHOWN DUE TO ON-GOING LANDFILLING OPERATIONS SINCE THE DATE OF THE AERIAL SURVEY.
3. FOR CLARITY NOT ALL SITE FEATURES ARE SHOWN.
4. EXISTING GAS MANAGEMENT SYSTEM TAKEN FROM DRAWING 1, PROVIDED BY WEAVER BOOS CONSULTANTS, ENTITLED "EXISTING GCCS 2014", DATED JULY 15, 2014.
5. FINAL GRADES PROVIDED BY WASTE MANAGEMENT, DRAWING 1, TITLED AS-BUILT GAS SYSTEM, DATED APRIL 2007.

N

0' 100' 200' 400'
SCALE

NO	REVISIONS	DRN	CHK	DATE

DRN
DES
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PREPARED FOR

WASTE MANAGEMENT

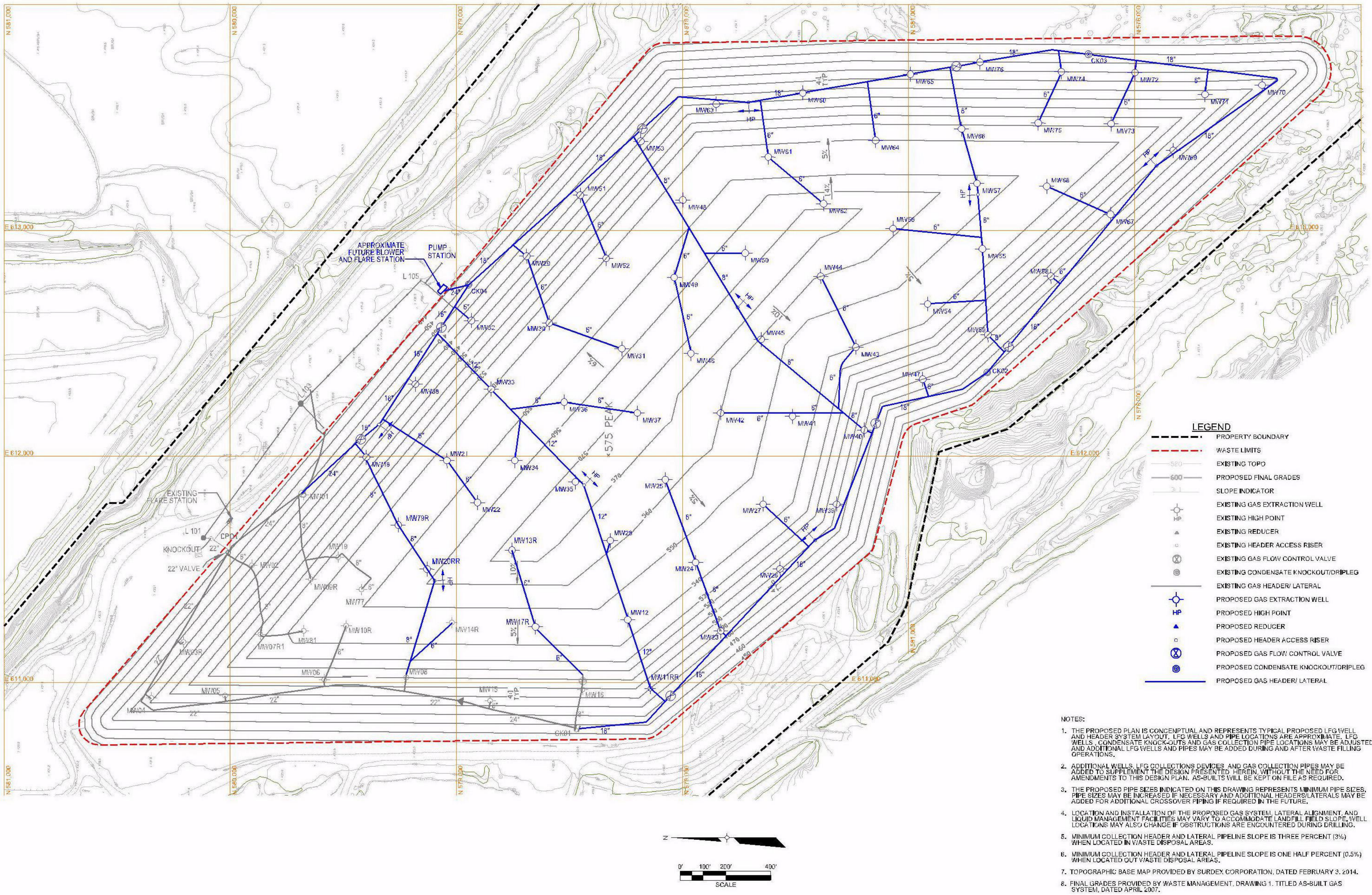
PREPARED BY

ENVIRONMENTAL INFORMATION LOGISTICS, LLC

COTTONWOOD HILLS RECYCLING AND DISPOSAL FACILITY - NSPS LANDFILL GAS MANAGEMENT SYSTEM PLANS

EXISTING GAS MANAGEMENT SYSTEM PLAN

DATE SEPTEMBER 2014
PROJECT NO 131203
FILENAME 002 CW EX GMSP 091214
SHEET NO 2 OF 4
FIGURE NO 2



LEGEND

	PROPERTY BOUNDARY
	WASTE LIMITS
	EXISTING TOPO
	PROPOSED FINAL GRADES
	SLOPE INDICATOR
	EXISTING GAS EXTRACTION WELL
HP	EXISTING HIGH POINT
	EXISTING REDUCER
	EXISTING HEADER ACCESS RISER
	EXISTING GAS FLOW CONTROL VALVE
	EXISTING CONDENSATE KNOCKOUT/DRIPLEG
	EXISTING GAS HEADER/ LATERAL
	PROPOSED GAS EXTRACTION WELL
HP	PROPOSED HIGH POINT
	PROPOSED REDUCER
	PROPOSED HEADER ACCESS RISER
	PROPOSED GAS FLOW CONTROL VALVE
	PROPOSED CONDENSATE KNOCKOUT/DRIPLEG
	PROPOSED GAS HEADER/ LATERAL

NOTES:

1. THE PROPOSED PLAN IS CONCENPTUAL AND REPRESENTS TYPICAL PROPOSED LFG WELL AND HEADER SYSTEM LAYOUT. LFG WELLS AND PIPE LOCATIONS ARE APPROXIMATE. LFG WELLS , CONDENSATE KNOCK-OUTS AND GAS COLLECTION PIPE LOCATIONS MAY BE ADJUSTED AND ADDITIONAL LFG WELLS AND PIPES MAY BE ADDED DURING AND AFTER WASTE FILLING OPERATIONS.
2. ADDITIONAL WELLS, LFG COLLECTIONS DEVICES AND GAS COLLECTION PIPES MAY BE ADDED TO SUPPLEMENT THE DESIGN PRESENTED HEREIN, WITHOUT THE NEED FOR AMENDMENTS TO THIS DESIGN PLAN. AS-BUILTS WILL BE KEPT ON FILE AS REQUIRED.
3. THE PROPOSED PIPE SIZES INDICATED ON THIS DRAWING REPRESENTS MINIMUM PIPE SIZES. PIPE SIZES MAY BE INCREASED IF NECESSARY AND ADDITIONAL HEADERS/LATERALS MAY BE ADDED FOR ADDITIONAL CROSSOVER PIPING IF REQUIRED IN THE FUTURE.
4. LOCATION AND INSTALLATION OF THE PROPOSED GAS SYSTEM, LATERAL ALIGNMENT, AND LIQUID MANAGEMENT FACILITIES MAY VARY TO ACCOMMODATE LANDFILL FIELD SLOPE. WELL LOCATIONS MAY ALSO CHANGE IF OBSTRUCTIONS ARE ENCOUNTERED DURING DRILLING.
5. MINIMUM COLLECTION HEADER AND LATERAL PIPELINE SLOPE IS THREE PERCENT (3%) WHEN LOCATED IN WASTE DISPOSAL AREAS.
6. MINIMUM COLLECTION HEADER AND LATERAL PIPELINE SLOPE IS ONE HALF PERCENT (0.5%) WHEN LOCATED OUT WASTE DISPOSAL AREAS.
7. TOPOGRAPHIC BASE MAP PROVIDED BY SURDEX CORPORATION, DATED FEBRUARY 3, 2014.
8. FINAL GRADES PROVIDED BY WASTE MANAGEMENT, DRAWING 1, TITLED AS-BUILT GAS SYSTEM, DATED APRIL 2007.

NO	REVISIONS	DRN	CHK	DATE

DRN
DES
CHK
APP

PREPARED FOR

WM WASTE MANAGEMENT

PREPARED BY

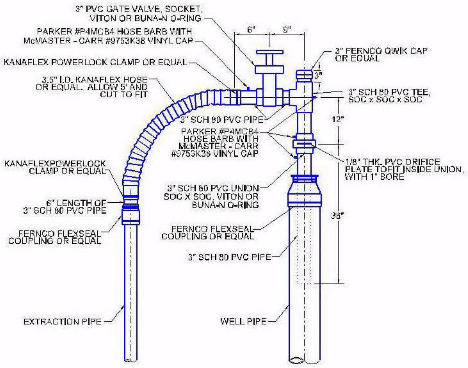
EIL ENVIRONMENTAL INFORMATION LOGISTICS, LLC

COTTONWOOD HILLS RECYCLING AND DISPOSAL FACILITY - NSPS LANDFILL GAS MANAGEMENT SYSTEM PLANS

PROPOSED GAS MANAGEMENT SYSTEM PLAN

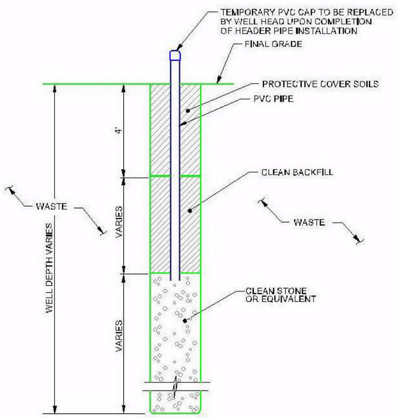
DATE	SEPTEMBER 2014
PROJECT NO	131203
FILENAME	003 CW PGMSP 091214
SHEET NO	3 OF 4
FIGURE NO	3

WM00138



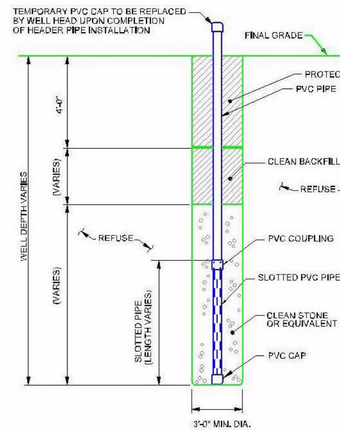
TYPICAL 3" WELL HEAD DETAIL 1

NTS



GAS EXTRACTION WELL (NO SLOT OR "STONE COLUMN") 2

NTS



GAS EXTRACTION WELL (SLOTTED) 3

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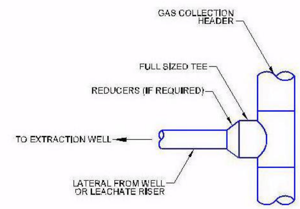

LATERAL CONNECTION DETAIL 7

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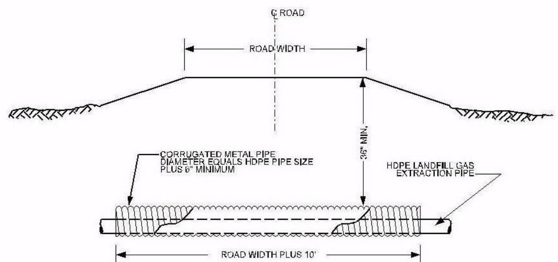
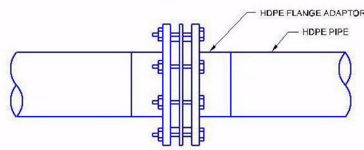


TYPICAL HEADER CASING 4

NTS

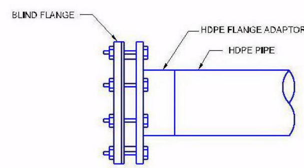
NOTES:

1. LOCATION OF ALL HEADER CASINGS TO BE FIELD DETERMINED.
2. GRADE HEADER CASING CROSS SLOPE TO A MINIMUM 5% SLOPE.



FLANGE CONNECTION (TYP) 5

NTS



BLIND FLANGE (TYP) 6

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NO | REVISIONS | DRN | CHK | DATE

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DES
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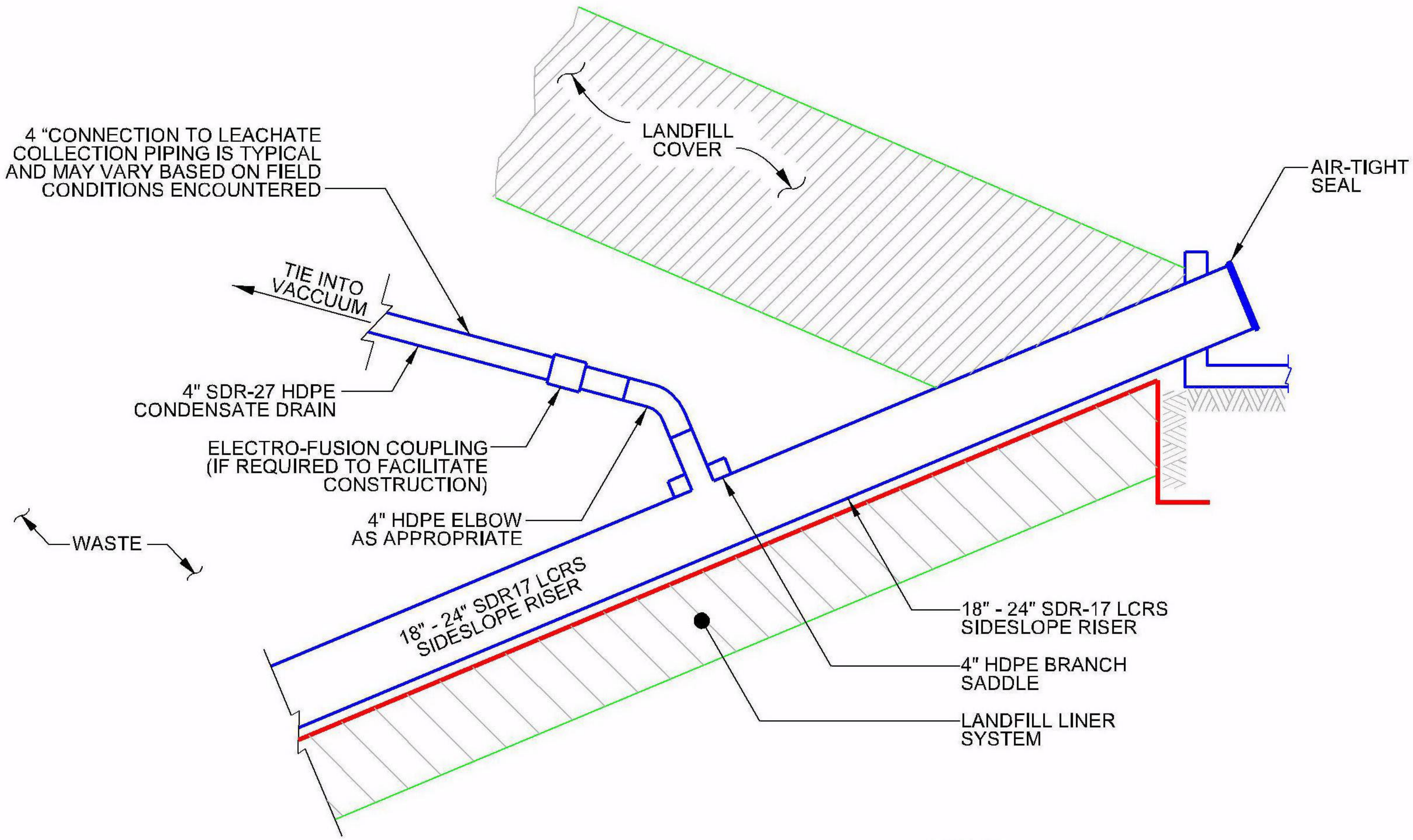
COTTONWOOD HILLS RECYCLING AND DISPOSAL FACILITY - NSPS LANDFILL GAS MANAGEMENT SYSTEM PLANS

GAS MANAGEMENT SYSTEM DETAILS

DATE SEPTEMBER 2014
PROJECT NO 131203
FILENAME 004 WAM DET1 091814
SHEET NO 4 OF 4
FIGURE NO 4

WM00139



NOTES:

1. HORIZONTAL COLLECTOR LOCATIONS AND ELEVATIONS ARE APPROXIMATE AND MAY BE ADJUSTED BY PROJECT ENGINEER OR PROJECT MANAGER TO ACCOMMODATE FIELD CONDITIONS AND FACILITATE CONSTRUCTION.
2. FILTER GEOTEXTILE IS ONLY REQUIRED IF BACKFILL IMMEDIATELY ABOVE TRENCH IS SOIL.
3. PERFORATION PATTERNS IS TYPICAL AND MAY VARY. PIPE SDR IN MINIMUM AND MAY BE THICKER. PIPE SIZES ARE TYPICAL AND MAY VARY AS NEEDED BASED ON FIELD CONDITIONS.

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FIGURE 1

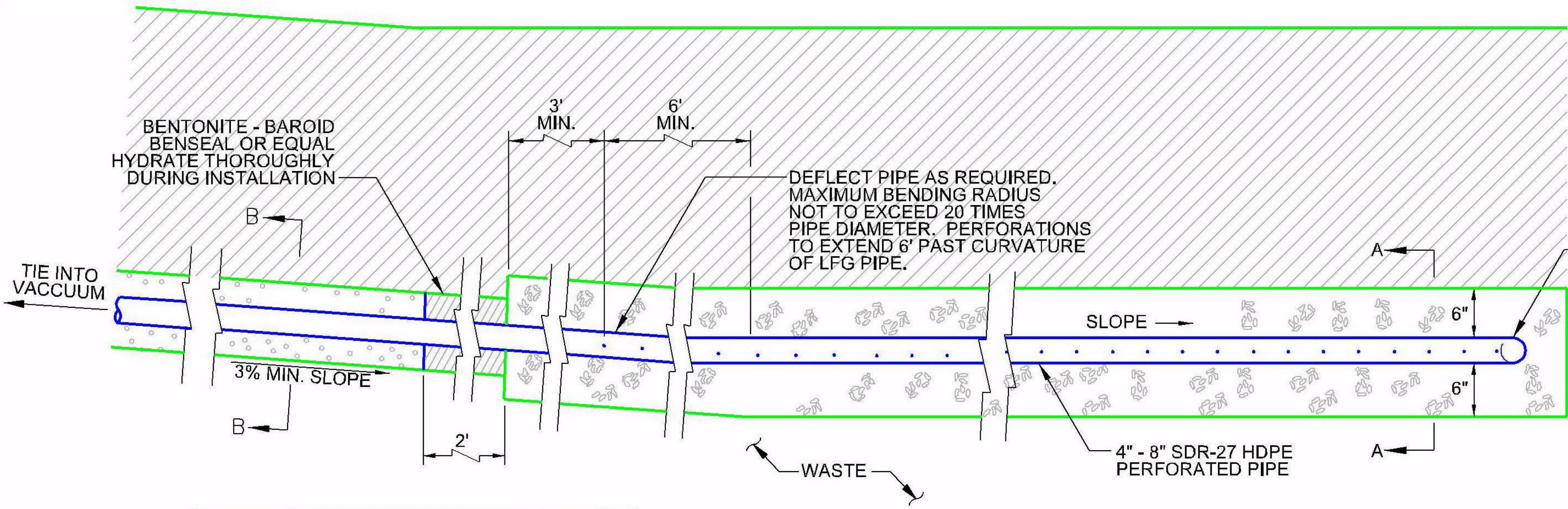
TYPICAL DRAIN TO LCRS SIDESLOPE RISER

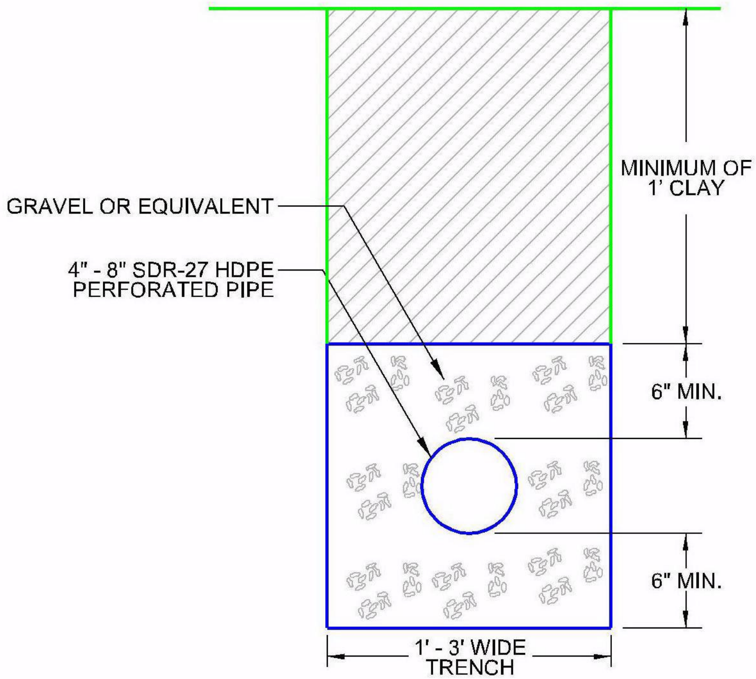
COTTONWOOD HILLS RECYCLING AND DISPOSAL FACILITY - NSPS LANDFILL

131203

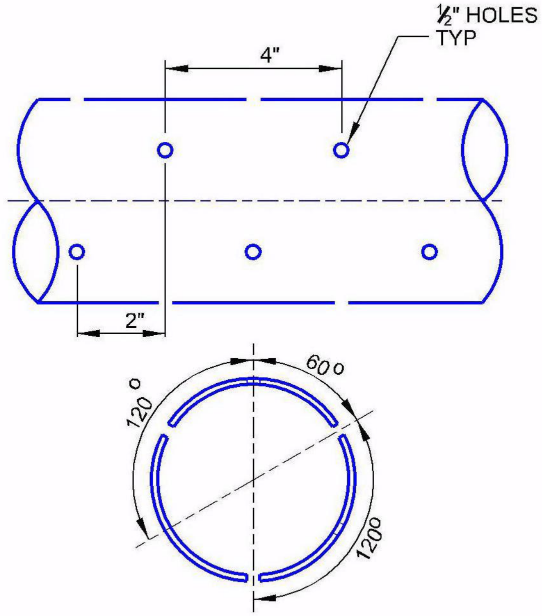
SEPTEMBER 2014

WM00140





SECTION B-B



LFG COLLECTION PIPE PERFORATION DETAIL

NOTES:

1. HORIZONTAL COLLECTOR LOCATIONS AND ELEVATIONS ARE APPROXIMATE AND MAY BE ADJUSTED BY PROJECT ENGINEER OR PROJECT MANAGER TO ACCOMMODATE FIELD CONDITIONS AND FACILITATE CONSTRUCTION.
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